UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

PUGET SOUNDKEEPER ALLIANCE, Plaintiff, v. ACE METAL CORPORATION, Defendant.	C17-524 TSZ MINUTE ORDER

The following Minute Order is made by direction of the Court, the Honorable Thomas S. Zilly, United States District Judge:

(1) The Court has received a paper copy of a letter from Edmonds Community College confirming completion of the ecological assessment required by the August 10, 2018 Consent Decree, docket no. 19. That letter and its attachments will be filed on the docket as proof of partial satisfaction of the Consent Decree.

(2) The Clerk is directed to send a copy of this Minute Order to all counsel of record.

Dated this 29th day of July, 2019.

William M. McCool
Clerk

s/Karen Dews
Deputy Clerk

EDMONDS COMMUNITY COLLEGE

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June 19, 2019

US Department of Justice
Environmental and Natural Resources Division
Law and Policy Section
P.O. Box 7415
Washington, D.C. 20044-7415

United States District Judge Thomas S. Zilly
U.S. District Court for the Western District of Washington
700 Stewart Street, Suite 15229
Seattle, WA 98101-9906

Dear Judge,

This letter is intended to confirm the completion of the ecological assessment of Big Gulch proposed in the Consent Decree in the matter of Puget Soundkeeper Alliance v. Ace Metal Corporation; 2:17-cv-00524-TSZ (W.D. Wash April 4, 2017).

Edmonds Community College Foundation received $5,000 from Ace Metal Corporation for the purpose of supplementing the costs of an ecological assessment of Big Gulch. These funds paid for faculty, staff and student salaries and benefits, transportation expenses, and indirect college overhead. The assessment included fish, wildlife, and water quality surveys in the Big Gulch basin conducted in Fall 2018. Faculty, staff, and students compiled and analyzed these data along with results from previous surveys in Big Gulch and comparative data from Japanese Gulch, a neighboring watershed in Mukilteo, Washington. A final report summarizing the new, historical, and comparative data and its implications for water quality in Big Gulch is enclosed and available online at https://www.academia.edu/38159730/.

Sincerely,

Thomas W Murphy

Thomas W Murphy, Anthropology Department Head

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Repatriating Salmon to Point Elliott:

Fish and Wildlife in bəka'ltiu (Mukilteo), 2012 - 2018

Thomas W Murphy, Grace Coale, Skyler Elmstrom, Kacie McCarty, Cali Drake, Lazarus Hart, Sarah Taylor, Bri Castilleja

Learn and Serve Environmental Anthropology Field (LEAF) School

Edmonds Community College

January 15, 2019

Cover photo: Adult male coho in spawning form, Big Gulch. 11/13/18

Table of Contents

Executive Summary

In an 1855 treaty at Point Elliott (bəka'ltiu or Mukilteo, WA) the United States promised Coast Salish nations that they could continue to hunt and fish in their usual and accustomed places in perpetuity; yet logging, stream realignments, military installations, pollution, and transportation infrastructure over the following century disrupted and impeded salmon access to local streams. A railroad spur built in the late 1960s to connect the waterfront railway to a Boeing plant above Japanese Gulch introduced additional barriers and by this time, if not sooner, humans had entirely blocked salmon access to the stream in the very shadows of the historic treaty. Students from Edmonds Community College in Lynnwood, WA. joined a collaborative effort in 2012 led by the City of Mukilteo and Snohomish County Airport, in consultation with Tulalip Tribes and Washington Department of Fish and Wildlife, to remove four major barriers to salmon migration in Japanese Gulch. As its name suggests, this stream is not only important to the First Peoples of this land but also to descendants of immigrants from Japan who lived in lumber company housing in the gulch during the early twentieth century.

Urban streams and their associated riparian zones in western Washington contain important fish and wildlife habitat in the midst of extensive human activities. Community college students are enhancing their own learning while assisting cities, counties, and tribes with monitoring of plants and animals in these urban ecosystems. This report summarizes the results of in-stream salmon spawning, wildlife, and water quality surveys in two streams in the heart and edges of Mukilteo conducted between 2012 and 2018. Students, faculty, and staff from Edmonds CC have conducted these surveys in Japanese and Big Gulches in response to requests from the City of Mukilteo and Snohomish County Airport. The data collected help municipalities preserve and sustain places and species of significant cultural importance to Coast Salish tribes, Japanese-American communities, and other local residents.

The surveys demonstrate that small numbers of adult coho (*Oncorhynchus kisutch*) have consistently come to Japanese Gulch to spawn for seven consecutive years. Chum returned to Japanese Gulch for just one out of seven years of observation. While stream restoration projects have opened the gulch to salmon, spawning in this stream is under threat from an invasive species, bittersweet nightshade (*Solanum dulcamera*), that has overrun prime spawning habitat in restored sections of the stream.

Big Gulch, like Japanese Gulch, originates at Paine Field Airport and flows to the salt water of Puget Sound. Coho returned to Big Gulch for four out of six years of monitoring in this watershed. Chum (*O. keta*) have returned for five out of six years of monitoring but the numbers have been quite variable and were dramatically lower this year than the previous year. The variability of salmon runs in Big Gulch coincides with a similar volatility in water quality samples, suggesting that water quality remains the primary threat to the viability of salmon in this stream.

For the past five years, researchers from Edmonds CC have monitored the gulches for evidence of a troubling phenomenon of salmon, especially coho, dying before spawning in urban areas of the Puget Sound basin. For four out of five years, service-learners have documented pre-spawn

mortality in Mukilteo streams. All three necropsies of female coho in Big Gulch in 2018 revealed evidence of pre-spawn mortality. In fact, three out of the four years that coho returned to Big Gulch, necropsies revealed 100% pre-spawn mortality resulting in a cumulative rate of 87.5% over five years of monitoring. Surveyors at Japanese Gulch found no dead female carcasses for analysis this year but over the same five years, pre-spawn mortality rates average just 40% in the recently restored stream. These local rates of pre-spawn mortality range from substantially to moderately higher than predicted by new prognostic models developed by scientists at the National Oceanic and Atmospheric Administration (NOAA) for forecasting premature deaths.

Recognizing salmon are part of a larger ecosystem, researchers from Edmonds CC document and maintain lists of wildlife observed in each basin. Prior to the beginning of this project, Mukilteo Wildlife Society already had a robust list of wildlife their members had recorded in Japanese Gulch. Teams of students, staff, and faculty have confirmed 13 mammals and 22 birds previously reported and added three each of additional mammals and birds as well as one amphibian to the list. At Big Gulch Saltwater Anglers of Mukilteo had documented seven species of mammals and birds in the 1990s, all of which researchers on this project have confirmed. They have also added 11 species of mammals, 17 species of bird, and one each of amphibians and reptiles (see appendix B).

This year, 228 students, staff, faculty, and community members contributed to service-learning activities as part of this project, these include salmon surveys, wildlife monitoring, water quality investigations, and eMammal data entry. 24 of these researchers returned from involvement in previous years, while 204 were new to the project. Overall, 805 students, staff, and community members have contributed to this community-based service-learning partnership over the past seven years. Participation has grown in recent years as faculty and students at Edmonds CC recognize the value of assisting local municipalities in endeavors to restore and conserve fish and wildlife habitat, especially in culturally and ecologically sensitive areas. This project serves as an example of the value of community-based citizen science in filling the monitoring and assessment gap in current salmon restoration projects throughout the Pacific Northwest.

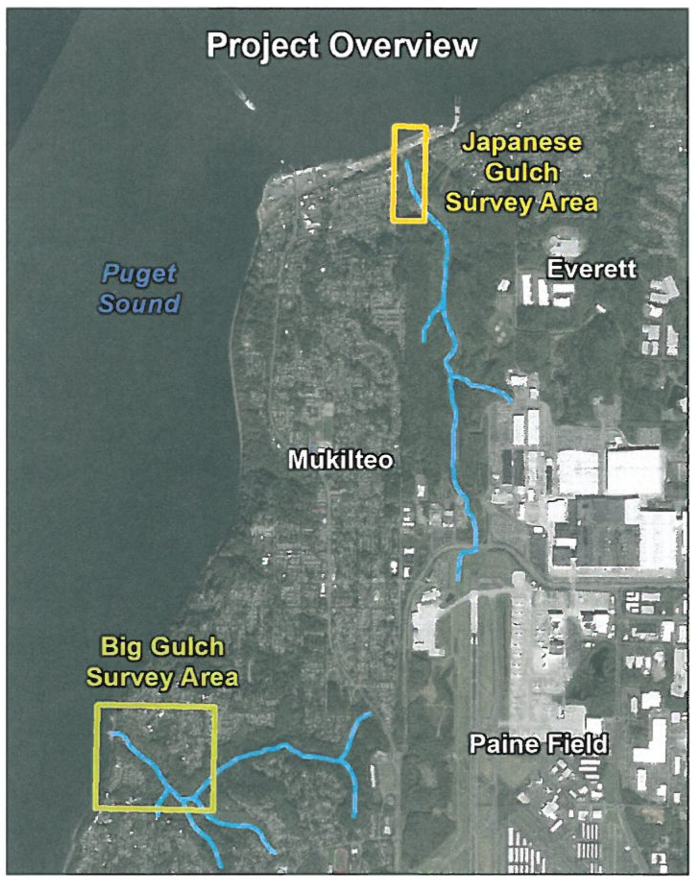

Figure 1: Salmon survey Locations in Mukilteo, WA

Site Descriptions

Big Gulch and Japanese Gulch are two of thirteen ravines entirely or partially within the confines of the City of Mukilteo in Snohomish County, WA. Japanese Gulch flows from south to north and drains approximately 1,000 acres of the City of Everett and 615 acres of Mukilteo and is located in the northeastern portion of the city limits. Japanese Gulch is near the site of the signing of the Point Elliott Treaty and was home to a community of Japanese mill workers from 1903 - 1930. Big Gulch flows from east to west and drains 1,600 acres from within the central/western portion of Mukilteo and its urban growth area (Mukilteo 2011: 28, 35). Both streams contain significant portions of lowland forested riparian zone and steep slopes with significant clearing and development in upper reaches. Suitable salmon spawning habitat is available in lower reaches, and the forested riparian zones provide urban wildlife corridors.

Image 1: Bittersweet nightshade (Solanum dulcamara) and Himalayan blackberry (Rubus armeniacus) obstructing spawning habitat in Japanese Gulch, 10/7/18.

Both monitoring sites are hardwood-dominated and feed directly into the Puget Sound. Along riparian forests in these gulches, the overstory is characterized by red alder (*Alnus rubra*), big leaf (*Acer macrophyllum*) and vine maples (*Acer circinatum*), and black cottonwood (*Populus balsamifera*), while the understory consists of a variety of ferns (sword, bracken, and wood - *Polystichum munitum*, *Pteridium aquilinum*, and *Dryopteris expansa*), salmonberry (*Rubus spectabilis*), huckleberry (*Vaccinum ovatum, V. parviflorum*), serviceberry (*Amelanchier alnifolia*), horsetail (*Equestrian spp.*), trailing blackberry (*Rubus ursinus)*, Nootka rose (*Rosa nutkana)*, devil's club (*Oploplanax horridus)*, and western crabapple (*Malus fusca*). While both sites show a heavy presence of English ivy (*Hedera helix*), English holly (*Ilex aquafolium)*, and Himalayan blackberry (*Rubus armeniacus)*, only Japanese Gulch shows the problematic presence of *Solanum dulcamara*, colloquially known by bittersweet or woody nightshade. Bittersweet nightshade (not to be confused with deadly nightshade, *Atropa belladona)* is classified as a weed of concern in King County where "control is recommended, especially in natural areas that are being restored to native vegetation and along stream banks where nightshade can interfere with fish habitat" (King County 2017). Bittersweet nightshade has invaded the recently restored sections of Japanese Gulch and is actively spreading and obstructing prime spawning habitat.

Japanese Gulch is culturally and ecologically significant because of its proximity to the site of the signing of the Point Elliott Treaty on January 22, 1855. The importance of this community of people, plants, and animals to surrounding tribes can be seen in its traditional name, bəka'ltiu (anglicized as Mukilteo), a Lushootseed word meaning "to swallow," "narrow passage" (Hess 1976, 32), and "a good place to camp" (Miss, et al. 2013, i; White 2009, 7). Representatives of Suquamish, Duwamish, Snohomish, Snoqualmie, Stillaguamish, Samish, Swinomish, Lummi, and other nations gathered in Mukilteo to meet with Governor Isaac Stevens, representing the United States. Partly under duress and despite internal disagreements, tribal leaders signed the treaty that would cede title of much of the Puget Sound region to the United States (Dover 2013). The jointly signed treaty secured for the tribes "the right of taking fish at usual and accustomed grounds and stations" (Treaty 1855). The Tulalip Tribes are a federally recognized tribal government representing Snohomish and other treaty signing nations that settled on a reservation, just north of Mukilteo and Everett near the present-day community of Marysville. The usual and accustomed treaty fishing areas of the Tulalip Tribes include the Mukilteo waterfront where the Snohomish people previously had a year round village and where their ancestors fished and gathered for thousands of years. Tulalip Tribal members continue to harvest chinook, chum, coho, pink, and steelhead salmon as well as clams, crabs, and shrimp along the shoreline (Sheldon 2010).

Image 2: Historic Japanese Gulch. Courtesy of Mukilteo Historical Society.

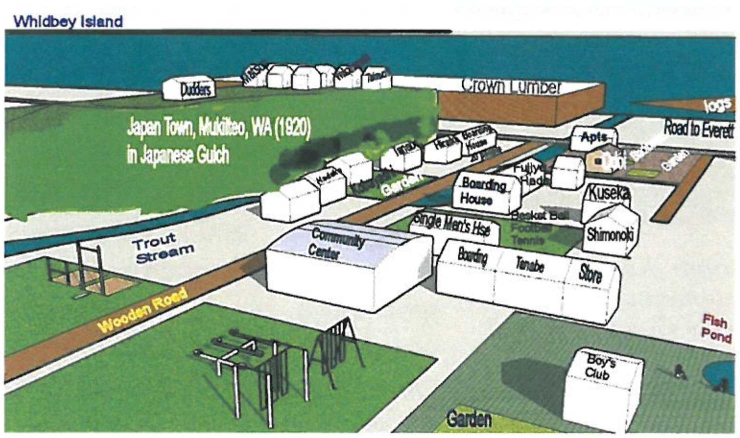

Image 3: Map by Mas Odoi. Courtesy of Mukilteo Historical Society.

Japanese Gulch would get its present name from the Japanese community that lived in company housing in the lower reach and on a nearby hill from 1903 - 1930. Mukilteo Lumber Company hired 35 Japanese citizens in 1903 to work in a mill located west of the mouth of the stream. The mill became known as Crown Lumber in 1909. This community eventually grew to about 100 Japanese laborers, many with spouses and children residing in the area. The mill workers and their families occupied several unpainted, single-story homes and a boarding

house laid out along a plank and dirt road stretching from the mill up the gulch. The mill closed in 1930, in the aftermath of the national financial collapse initiating the Great Depression, and the last building from the mill operation would burn to the ground in 1938. The Japanese community dispersed and some would end up incarcerated and interned during World War II. War would also change the gulch with the construction of the U.S. Air Force Tank Farm in 1950 during the Korean conflict. The Tank Farm covered the mouth of the stream which would subsequently enter salt water via a long culvert. In the late 1960s, the growth of Boeing would result in the construction of a railroad going north and south through the gulch, obstructing salmon passage, and changing the direction and rate of flow in the stream by moving the stream out of its historic channel and into a straightened chute east of Mt. Baker Ave (reduced to an access road for Mukilteo Water and Wastewater) and the west side of the railroad tracks (Love, et al. 2013; Miss, et al. 2013; Odoi, nd; Nohara 2010; Mukilteo 2016, 6).

Image 4: 1947 aerial photo of Japanese Gulch. Courtesy of City of Mukilteo.

Image 5: 1974 aerial photo of Japanese Gulch. Courtesy of City of Mukilteo.

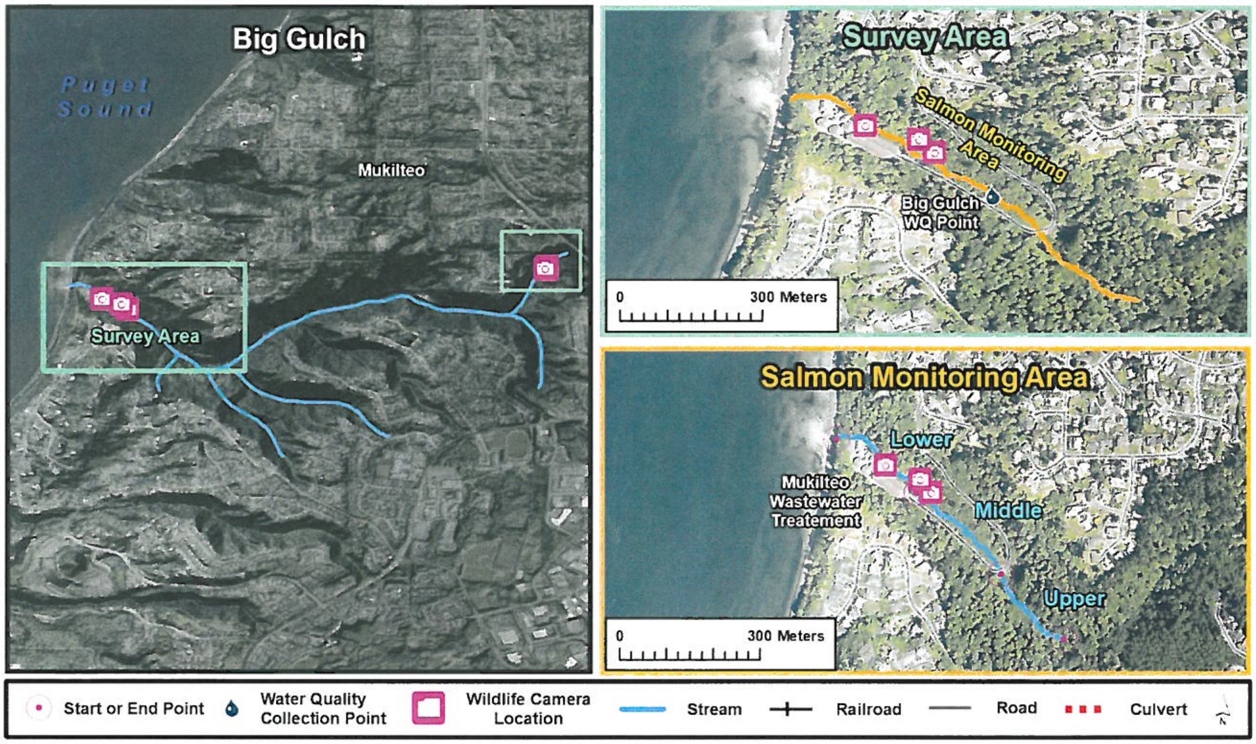

Figure 2: Big Gulch watershed, salmon survey transect, water quality test point, and wildlife camera locations

Literature Review

The Shoreline Master Program for the City of Mukilteo (2011) identifies both Big[1] and Japanese Gulch[2] as salmon bearing for coho and chum. In 1993, 1996, and 2000 Big Gulch was beset with multiple chemical spills that originated at B.F. Goodrich/Tramco at Paine Field and Iconn Sports International on the 4400 block of Chennault Beach Road (Chemical Spills 1994; Concerted Effort 1995; Archipley 1994, 1995 & 1996: Carter 1996; Pickus 2000). In response to these potential impacts Saltwater Anglers of Mukilteo, who had adopted Big Gulch in 1991 with support from Adopt-A-Stream Foundation, expanded monitoring efforts previously focused on

[1] *Big Gulch:* In order to facilitate ease of collection and organization of field data records for analysis of salmon monitoring survey results the project leadership team in 2015 split Big Gulch into 3 sections: lower, middle, and upper. At Big Gulch, the lower section began near the mouth of the stream just upstream from where the water enters the culvert under the railroad [N 47.91151°, W 122.32080°] and ended at the intersection of an overhead black pipe and the stream [N 47.91048°, W 122.31858°]. The middle section continued from this point, past the wastewater treatment plant until shortly after the bridge for the sewage treatment access road [N 47.90901°, W 122.31620°]. The upper section continued past this point until a second large log jam covers the stream [N 47.90777°, W 122.31435°]. This administrative distinction between stream reaches continued through the 2018 salmon survey.

[2] *Japanese Gulch:* Project leadership identified lower, middle, and upper reaches in Japanese Gulch in 2015. The start point of the lower section began at the entrance to the culvert under Mukilteo Lane at approximately N 47.95024°, W 122.29352° and continued upstream to the beginning of the salmon ladder at the mouth of the first culvert under the railroad spur. The middle section began at the salmon ladder [N 47.94965°, W 122.29306°] and terminated shortly after the upstream culvert opening [N 47.94153°, W 122.29323°]. The upper section resumed upstream of the first culvert under the railroad through the entire restored historic channel, until the stream exits the second culvert under the railroad. The survey ended where the new baffle separates the previous engineered channel from the currently restored historic channel at the mouth of the second culvert [N 47.94796°, W 122.29263°].

stream structure, flow, and water quality to include salmon counts (Morton 1996; Pierides 1996).

After reading the annual technical report on this project this past fall, Jake Jacobson, formerly of Saltwater Anglers of Mukilteo and a retired Snohomish County Water Steward, shared his field notes and a binder full of news stories, technical reports, data sheets, and letters related to Big Gulch with Dr. Murphy on Nov. 1, 2018. In the mid to late 1990s Saltwater Anglers counted adult coho (*Oncorhynchus kisutch*) in the same stretch of the stream that citizen scientists from Edmonds CC would later monitor. Over a dozen survey dates they counted from zero to 31 coho. They noted the presence of cutthroat trout (*O. clarkii*) but did not provide consistent counts and saw no chum (*O. keta*).[3] Saltwater Anglers data from surveys in 1995 to 1998 with positive results appear in Figure 3.

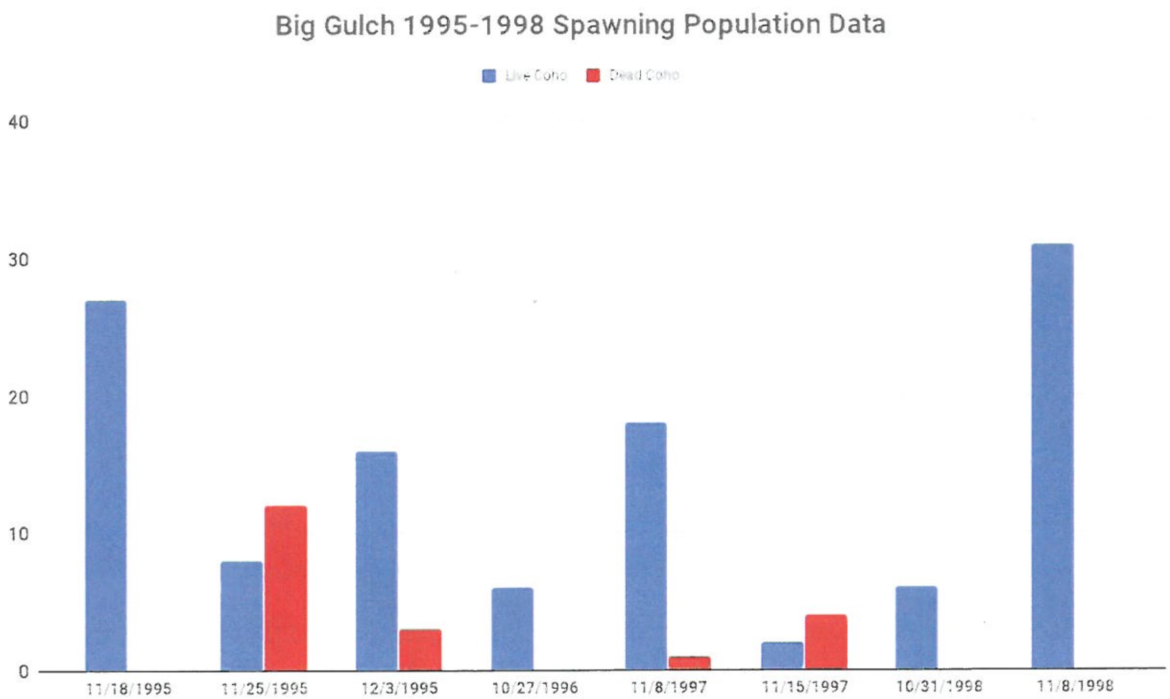

Figure 3: Saltwater Anglers of Mukilteo salmon survey data, 1995-1998. Courtesy of Jake Jacobson.

Until recently salmon access to lower Japanese Gulch was impeded by four primary blockages from tank farm and transportation infrastructure. The city, Paine Field Airport (Snohomish County) and Edmonds CC partnered on an effort to remove the barriers that had limited salmon

[3] Jake Jacobson speculates that chum began appearing in Big Gulch after Brackett's Landing Foundation began adding chum fingerlings from school and neighborhood hatcheries to nearby Lund's Gulch. Dr. Murphy checked in with Duane Uusatilo from Brackett's Landing Foundation and confirmed that they began raising chum, in addition to coho, in the "mid-1990s" and first saw chum in Lund's Gulch in "1997/1998." Over the past three years service-learning students from Edmonds CC, Meadowdale High School, St. Thomas More Elementary School have assisted Brackett's Landing Foundation with their neighborhood and classroom hatcheries. During that time they only been releasing chum.

access since at least the late-1960s.[4] This effort led to the installation of baffles and boulders to slow and deepen water flow in culverts under Mukilteo Lane and the Boeing railroad spur, construction of two fish ladders, and a realignment of the stream from an engineered channel alongside the railroad back to its historic, meandering channel. Positive impacts for fish were rather immediate. After the removal of the first barrier to fish migration and during the construction of a three-tiered fish ladder in late September and October of 2010, contractors from Adopt-A-Stream Foundation conducted an electrofishing survey and observed juvenile cutthroat and coho in the stream (Love, at al. 2013; Ramos 2014).

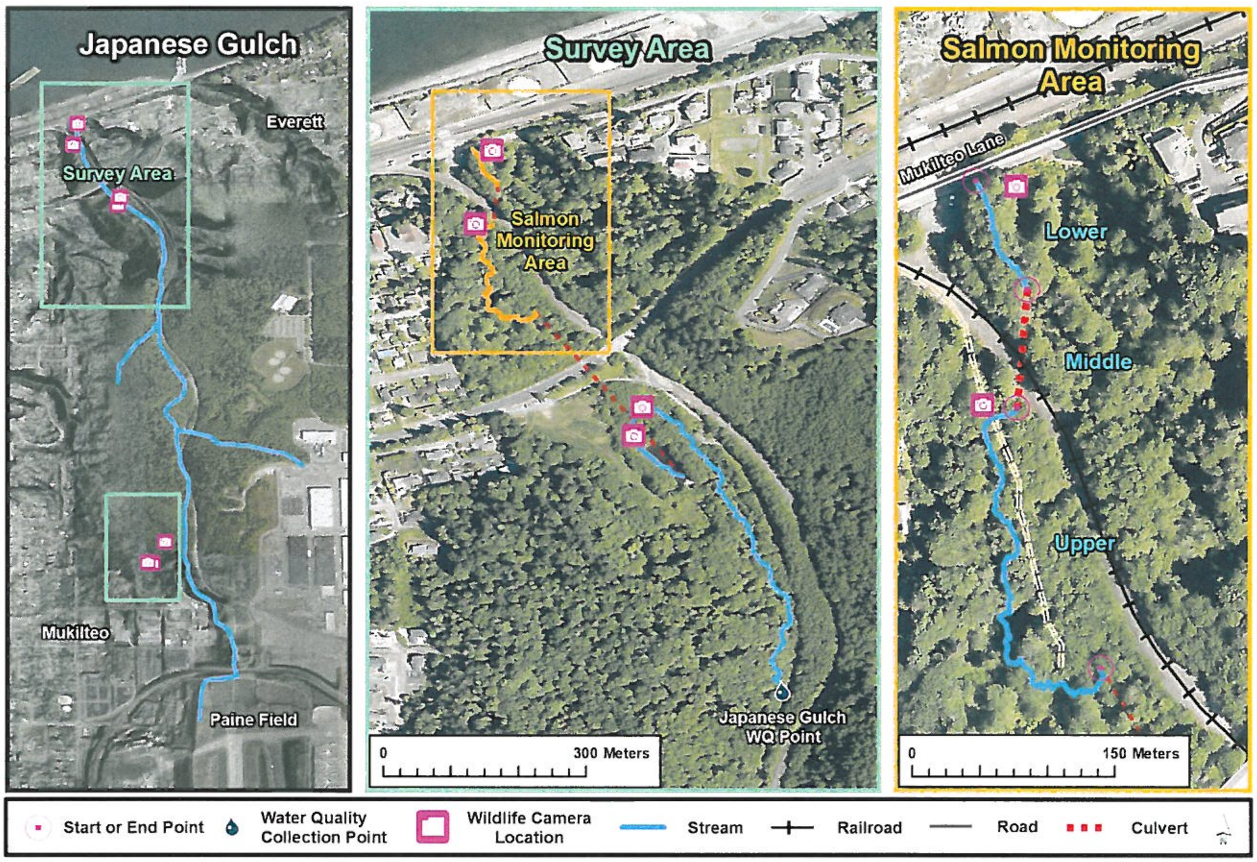

Figure 4: Japanese Gulch watershed, salmon survey transect, wildlife camera and water quality test point

After the stream restoration project encountered archaeological artifacts from the early twentieth century Japanese settlement in the lower portion of the gulch, Edmonds CC and contractors

[4] Jake Jacobson's field notes record observations of one dead and one live "fish" (no species indicated) at Japanese Gulch on Nov. 19, 1995 beneath the lower railroad culvert (presumably the Boeing spur, not Burlington Northern tracks further below). His binder also included a 1995 fish use survey by The Watershed Company that found 25 coho fry upstream from 5th Street and concluded "There is little doubt that these fish were planted and are not the progeny of adults that entered the creek on their own from Possession Sound. An absolutely impassible upstream migration barrier for fish exists at 5th Street in the form of a many-foot vertical plunge into an intake shaft (the 'elephant trap') and a piped section with a flume outfall under 5th Street" (The Watershed Company 1995).

from AMEC assisted with an archaeological survey and excavation during the summer of 2012 (Marine 2013; Murphy & Ryan-Peñuela 2013). Archaeology students produced posters featuring leather, ceramic, and glass artifacts found at Japanese Gulch, copies of which they donated to Mukilteo Historical Society (Pickard, et al. 2012; Taylor, et al. 2012; Choairy de Almeida, et al. 2012; Bolieu, et al. 2012; Donovan, et al. 2012). Following the archaeology, contractors completed the stream realignment and restoration efforts in October of 2012. Within two weeks of the completion of the stream reconstruction, service-learning students documented adult coho spawning in the creek (Murphy, et al. 2013b).

The Japanese Gulch Creek Advance Stream Mitigation Project and an earlier Snohomish County Airport Wetland Mitigation Banking Program are precedent-setting endeavors. The earlier project included the construction of the Narbeck Wetland Sanctuary in Everett, WA. and was the first Wetland Mitigation Banking Program in the state. As such, it enabled the airport to earn credits for "a more holistic set of environmental functions and diverse habitats" than would have been possible without the ability to bank credits in advance of a development project's wetland impacts. Following the former success, the airport sought mitigation options downstream from its anticipated future upland impacts "that could actually make a difference in fish habitat and use." Washington Department of Fish and Wildlife (WDFW) recommended the removal of fish barriers at the mouth of Japanese Gulch that "had been at the top of their list of preferred projects for years." A partnership with the City of Mukilteo, which served as an in-lieu fee agent of WDFW and made additional investments of its own, facilitated the removal of four key barriers to salmon in lower Japanese Gulch. Students, staff, and faculty from Edmonds CC played critical roles in conducting archaeological and ecological monitoring for an historic project that has essentially repatriated salmon to Point Elliott. Enthusiasm, planning, collaboration, political support, and personal relationships were all vital components of the project's successes (Ramos 2014). The partnership between the city, airport, and college in the Japanese Gulch Fish Passage Project earned a 2040 Vision Award from the Puget Sound Regional Council (Potter 2012).

In 2013 an electrofishing survey by the Skagit River System Cooperative targeted juvenile salmonids and documented several juvenile species using Japanese and Big Gulch. In the lower reaches of both streams they found juvenile cutthroat (*Oncorhynchus clarkii*), coho (*O. kisutch*), and chum (*O. keta*). In Big Gulch they also found ESA listed juvenile chinook (*O. tshawytscha*). While the authors from Skagit River Cooperative assume that cutthroat, coho, and chum may be natal in these streams, neither Japanese nor Big Gulch is large enough to support spawning chinook. The juvenile chinook, they conclude, must be non-natal users of this habitat (Beamer, et al. 2013). Until 2017, no known observers had documented adult chum in Japanese Gulch (Murphy, et al. 2017; Murphy, et al. 2018).

At the city's request students from Edmonds CC began monitoring wildlife at Big and Japanese Gulch in January 2012 and salmon later that year, after completion of the archaeology project and stream restoration. Students monitoring wildlife in November 2012 documented the first return of adult coho to Japanese Gulch since the restoration project. Following that observation,

the city and airport requested more systematic surveys of salmon spawning at both gulches beginning in November of 2013. That year students documented chum spawning in Big Gulch and coho spawning in Japanese Gulch. These results confirmed that coho had returned for a second year in a row to Japanese Gulch and that chum were using Big Gulch to spawn (Murphy, et al. 2013).

During 2014, the number of salmon observed increased substantially, and students documented an additional salmon species in one of the streams. Teams observed both coho and chum in Big Gulch; whereas, in 2013, they observed only chum. Researchers added necropsies to their methods and documented a female coho at Big Gulch with 100 percent of her eggs retained. This finding indicated that at least some members of one species of salmon were dying in this urban stream before they could spawn. Just as in the previous year, surveyors observed only coho at Japanese Gulch. The 2014 annual report initiated lists of known fish and wildlife in each gulch, documenting six new species in Japanese Gulch while confirming 27 reports of species from other sources. A list of 34 species at Big Gulch initiated an effort to create a list of known fish and wildlife using this particular basin (Murphy & Coale 2015).[5]

In 2015, surveyors from Edmonds CC documented even higher numbers of chum in Big Gulch and smaller numbers of coho in Japanese Gulch. Six necropsies showed that deceased female chum at Big Gulch had successfully spawned. Likewise, two necropsies at Japanese Gulch found no evidence of pre-spawn mortality on either female coho examined. Surveyors added two new species each to lists of fish and wildlife in these basins and began collecting chemical and bacteriological water quality data in September of 2015. These data initially indicated generally viable salmon habitat in each stream (Murphy, et al. 2016a).

Water quality data took on increasing significance in the following year, 2016. Students and staff recorded low numbers of coho in both streams that year but no chum. Two-thirds of the necropsies on coho females in 2016 indicated that prespawn mortality was an ongoing problem. A newly implemented macroinvertebrate survey documented caddisfly, mayfly, stonefly, scud, aquatic worm, and midge in both creeks, leech in Japanese Gulch, and blackfly in Big Gulch and resulted in a "fair" rating of the health of both streams. Chemical and bacteriological sampling found the streams to be in a habitable range for salmon with a couple of key exceptions. Surveyors observed a spike in *Escherichia coli* in Big Gulch in May and June of 2016 that returned to normal levels after city officials identified and corrected a potential source of fecal coliform. Students documented high pH, low alkalinity, and high turbidity that coincided with a storm event that should have brought chum back to Big Gulch in 2016. In Japanese Gulch, surveyors also documented a significant amount of polystyrene beads, a form of plastic pollution observed but not reported the previous year. Distribution and density patterns suggest that a ruptured and submerged float in the detention pond above 5th Street was the likely source and recommended efforts to stem the flow and clean up the beads (Murphy, et al. 2017).

[5] Field notes and binder provided by Jake Jacobson on Nov. 1, 2018 included some previously unknown observations of wildlife that have been added to Appendix B of this report.

The 2017 survey season documented record numbers of chum in Big Gulch and their presence in Japanese Gulch. Coho continued to return to both streams and researchers again documented 100% coho pre-spawn mortality in Big Gulch. Surprisingly, necropsies indicated that three out of eight female chum in Big Gulch also died before spawning. Service-learners also noted that a bittersweet nightshade (*Solanum dulcamera*) invasion had significantly eroded the newly restored salmon habitat in Japanese Gulch. New wildlife species documented that year included black bear (*Ursus americanus*) and flying squirrel (*Glaucomys sp?*) (Murphy, et al. 2018)..

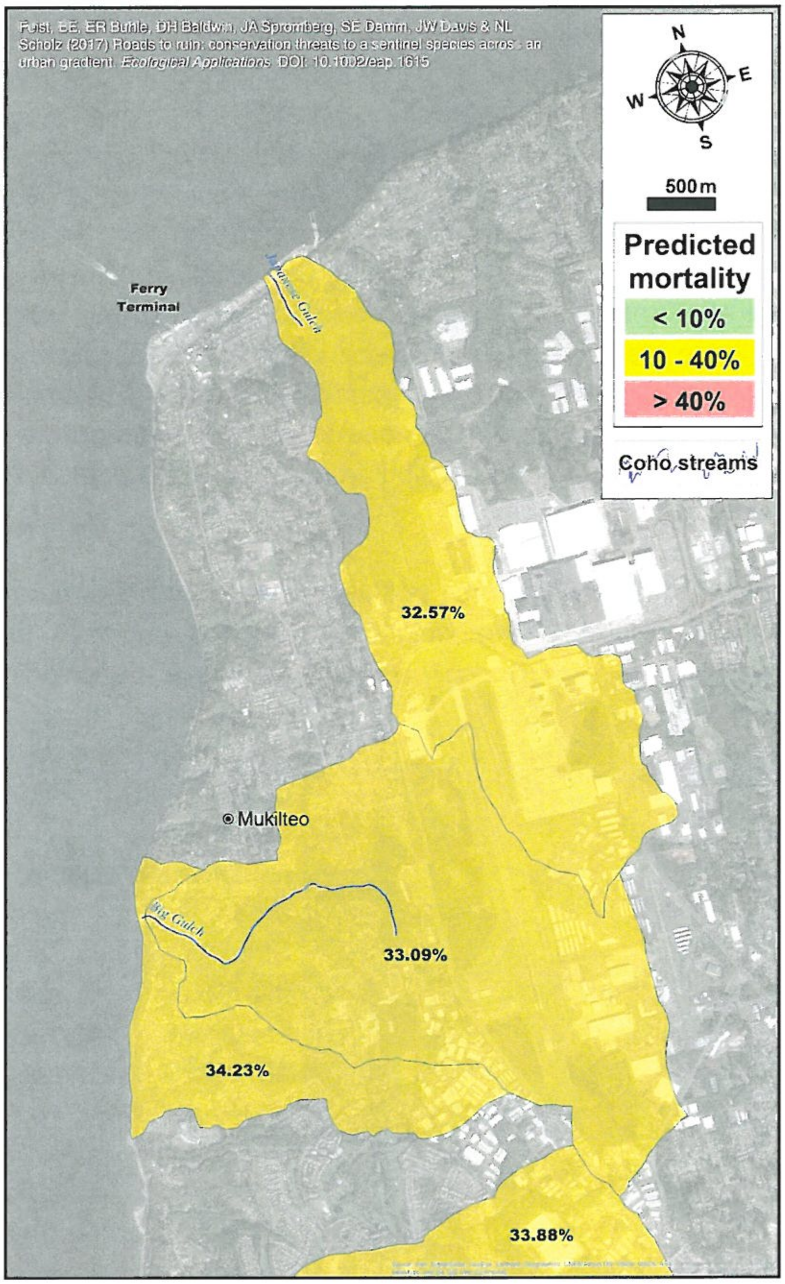

Figure 5: Predicted rates of coho pre-spawn mortality. Courtesy of Blake Feist.

While removing barriers and restoring habitat in places like Japanese Gulch are important for re-establishing salmon populations, they are insufficient on their own. Monitoring of previous restoration projects from the 1990s in the Seattle area revealed erratic behavior and high numbers of coho dying before they had a chance to spawn. Surveys between 2002 and 2009 in Seattle's Longfellow Creek documented "premature spawner mortality rates that ranged from 60-100% of each fall run" (Scholz, et al. 2011, 1). "From 1999 to present, Wild Fish Conservancy has documented alarming rates of coho prespawning mortality in Seattle area streams, ranging from 17-100%" (Wild Fish Conservancy 2008, 1). Another citizen science project, Community Salmon Investigation (CSI) for Highline, has recorded coho prespawn mortality rates from 33 to 95 percent in Miller and Walker Creeks between 2012 and 2016 (Ostergaard 2015; Ostergaard 2017). None of these

studies have found a similar phenomenon impacting significant numbers of chum.

A team of scientists from the National Oceanic and Atmospheric Administration (NOAA) conducted an extensive analysis of prespawn mortality in 51 different watersheds in the Puget Sound region (Feist, et al. 2017). They evaluated "factors that affect runoff quality including patterns of land use and land cover, amounts of impervious surfaces, human population density, roadways, traffic intensity, and annual summer and fall precipitation patterns" to generate a model for predicting rates of prespawn mortality (Vogel 2017). The map of predicted mortality in the study forecasts a general rate of 10 to 40 percent for Mukilteo, making it a high priority area for green stormwater infrastructure (Feist, et al. 2017). Blake Feist, lead author on the new study, generously provided Edmonds CC with a more detailed map and a prediction of 33.09 percent coho prespawn mortality for Big and 32.57 percent for Japanese Gulch (Fig. 5). Over the previous four years, students and staff at Edmonds CC working with small samples, have found prespawn coho mortality rates of 40 percent in Japanese and 80 percent in Big Gulch, moderately and substantially above those predictions (Murphy, et al. 2017). In order to protect the investments made in the removal of barriers and the expansion of in-stream spawning habitat, the City of Mukilteo and Snohomish County Airport need to address the stormwater runoff coming from the broader watersheds as the primary culprit in deaths of coho attracted to potential spawning habitat in these streams.

Coho appear to be especially sensitive to nonpoint source pollution coming from stormwater runoff. Scientists from NOAA earlier concluded, "The weight of evidence suggests that freshwater-transitional coho are particularly vulnerable to an as-yet unidentified toxic contaminant (or contaminant mixture) in urban runoff. Stormwater may therefore place important constraints on efforts to conserve and recover coho populations in urban and urbanizing watersheds throughout the western United States" (Scholz, et al. 2011). "Extensive forensic research has ruled out stream temperature, dissolved oxygen, spawner condition, tissue pathology, pathogens or disease, and other factors commonly associated with fish kills in freshwater habitats" (Fiest, et al. 2017, 2; Scholz, et al. 2011). Experiments under controlled settings have shown that exposing coho to unfiltered highway runoff results in 100 percent mortality while pretreating highway runoff with soil infiltration similar to that in green infrastructure removes the causes of

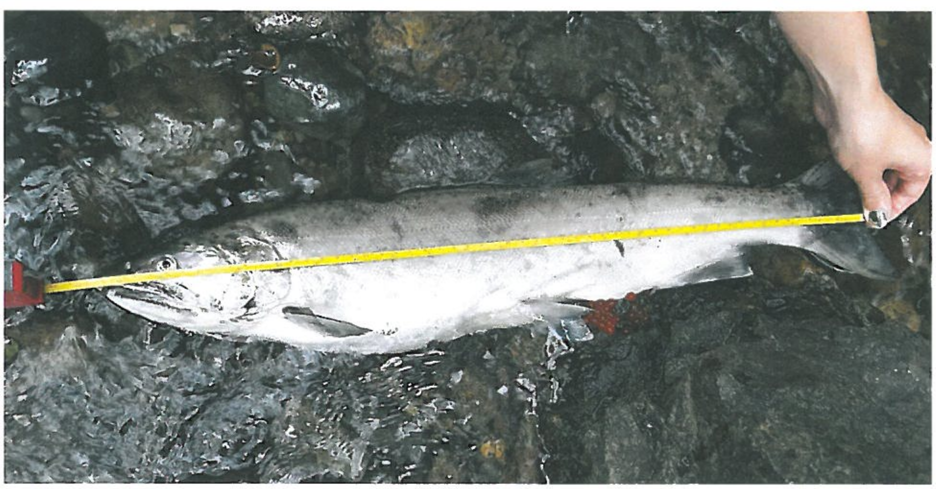

Image 6: Dead coho female with eggs at Big Gulch, 10/30/18.

mortality (Spromberg, et al. 2014 & 2016). "A major take-home of the work," NOAA scientist Nat Scholz reports is that the chemicals "causing the most problems are coming from motor vehicles. Put simply, the greater the traffic density within a given geographic area, the stronger the association with the mortality syndrome" (Northwest Treaty Tribes 2017). Most recently, a team of scientists led by Katherine Peter from the Center for Urban Waters at the University of Washington implicated tire wear components as a likely culprit in coho deaths (Peter, et al. 2018). Researchers have concluded, "Wild coho populations cannot withstand the high rates of mortality that are now regularly occurring in urban spawning habitats. Green storm water infrastructure or similar pollution prevention methods should be incorporated to the maximal extent practicable, at the watershed scale, for all future development and redevelopment projects, particularly those involving transportation infrastructure" (Spromberg, et al. 2016, 398). For successful restoration of coho populations, stream restoration projects need to include the installation of upland green infrastructure to filter stormwater before it enters the stream.

Image 7: Rain garden feasibility in Perrinville (Snohomish Conservation District 2016)

Green infrastructure uses rain gardens, bioswales, green roofs, pervious pavement, etc. to mimic natural processes in the management of stormwater and thereby improve water quality in urban streams. A door-to-door and online survey of residents of the Perrinville watershed in the cities of Edmonds and Lynnwood, just a few miles south of Big and Japanese Gulch revealed a strong residential preference for the aesthetics of rain gardens over typical lawn landscaping. Nine out of ten residents, most of whom currently have lawns, preferred the appearance and appreciated the environmental benefits of rain gardens. While the residents expressed a desire for technical and financial assistance, voice in the plant selection, and some concerns about maintenance, 89 percent expressed a willingness to install rain gardens if their needs were met. Homeowners even stated their willingness to invest an average of $1,225 as well as their own labor towards the cost of installing and maintaining rain gardens (Murphy, et al. 2016b; Barojas, et al. 2016; Snohomish Conservation District 2016). Cultural Anthropology students at Edmonds CC expanded these surveys in spring 2018 into non-English speaking households and also found a strong preference for rain gardens and a willingness to install them if financial and technical barriers are addressed (Chaercha, et al. 2018; Kutz, et al. 2018; Nam, et al. 2018; Nguyen, et al. 2018; Wang, et al. 2018; Yue, et al. 2018). These results are particularly hopeful for local municipalities because of evidence that bioretention through on-site facilities such as rain

gardens can reduce high flows and remove the toxic and lethal contaminants from urban streams that cause coho pre-spawn mortality (McIntyre, et al. 2014; Spromberg, et al. 2014; Zimmer, et al. 2007).

Municipalities are key components of regional efforts to protect and restore the Puget Sound. An ethnographic study by students, staff, and faculty from Edmonds CC demonstrated that cities and counties in the region face some significant barriers in their efforts to implement green infrastructure and maintain water quality in local communities. While implementation of low impact development standards is increasing in the Puget Sound basin, municipalities face the challenge of ensuring that proper maintenance of on-site facilities is occurring on private property, conducting better cost and benefit analysis using principles of green economics, retrofitting legacy infrastructure, and facilitating more effective communication across municipal divisions. While rain gardens have been widely implemented across municipalities in the Puget Sound region, wildlife corridors have received far less implementation (Fig. 5; Murphy, et al. 2015). This makes the City of Mukilteo's efforts to address the needs of wildlife as well as those of water quality particularly notable.

A survey of the literature reveals the importance of Japanese and Big Gulch as salmon-bearing tributaries to Puget Sound and of municipalities in their protection. Restoration of Japanese Gulch has brought salmon back to Point Elliott but the numbers remain very small. Big Gulch is significant because of the presence of juvenile Chinook, a species listed under the Endangered Species Act, and returns of coho and chum. While both streams contain important salmon habitat, lingering questions remain about deficiencies in water quality and invasive species that may be undermining their long-term viability as

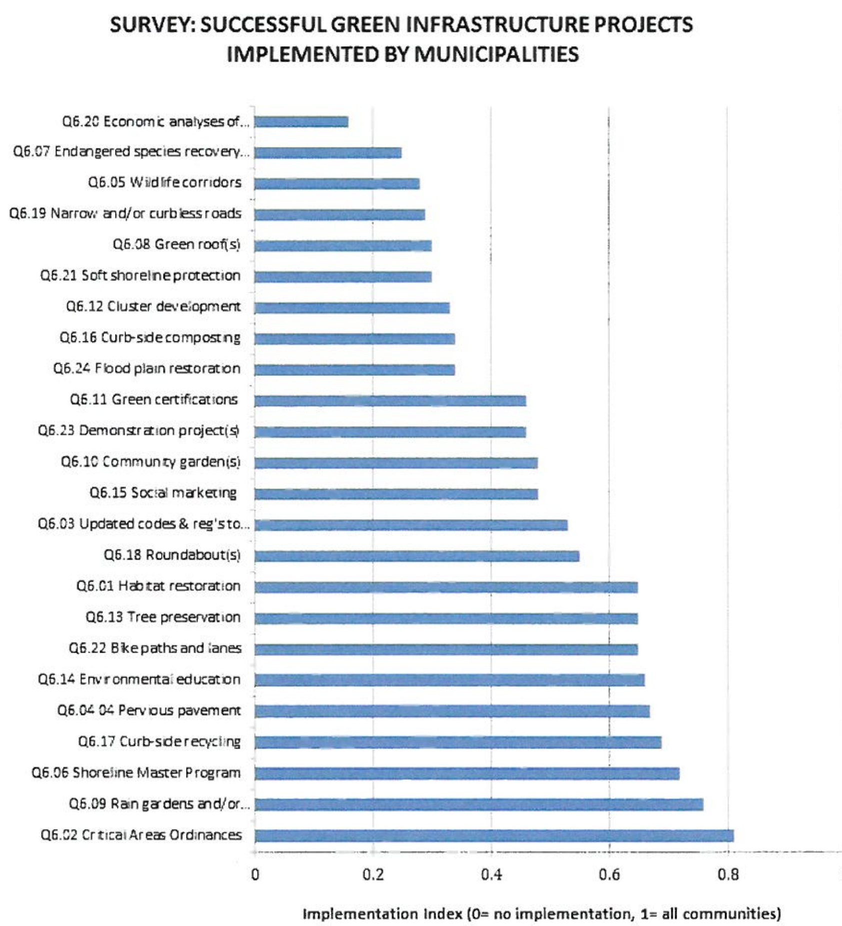

Figure 6: Survey of Puget Sound municipal employees on green infrastructure implementation (Murphy, et al. 2015)

spawning habitat. Additional research is needed to establish the extent of pre-spawn mortality, determine the viability over a longer term of coho and chum population in both gulches, document wildlife use of these corridors in urban areas, and to address water quality issues.

Research Questions

The research purpose of fish and wildlife surveys in Big Gulch and Japanese Gulch is to identify species present in these respective Salish Sea tributaries and their associated riparian zones. Research questions follow below:

- Which wildlife species are present at Japanese and Big Gulch?
- Are salmon present? Which species?
- Are salmon spawning in Big Gulch and Japanese Gulch? Which species?
- Is there evidence of pre-spawn mortality in these streams? At what rates?

During 2014, a team of service-learning students from the University of Washington contributed to this project by developing a fully-functioning prototype of a geographic information system (GIS) and an associated database with the intended purpose of geographically organizing data from field observations collected by community college students. With critical technical support from then student and now alumnus, Skyler Elmstrom, this system has helped organize the results of the salmon monitoring and wildlife surveys for the past four years. This innovation allows researchers to answer additional questions and evaluate geographic trends such as:

- How are the salmon geographically distributed in these streams?
- Where are the most common areas for egg deposits and redds?

In 2015, in addition to the salmon and wildlife monitoring, Edmonds CC initiated water quality monitoring under the leadership of Mary Whitfield, Chemistry Instructor, and Kacie McCarty, Anthropology Lab and Field Technician. This data collection continued through 2018. The data collected allow researchers to quantify each stream's water quality over time and enable valuable comparisons between potential trends in water quality and the fish and wildlife data observed in the field. Relevant research questions include the following.

- What water quality conditions exist at Big Gulch and Japanese Gulch?
- Are water quality conditions conducive to viable habitat for salmon and other wildlife?

Research Methods

In order to execute a three tiered approach including salmon surveys, wildlife monitoring, and water quality sampling; Dr. Thomas Murphy trained a series of team leaders from his advanced field-based Human Ecology courses who, in turn, supervise surveyors in the field from a variety of service-learning classes across campus. In 2018, Anthropology Field Technician, Grace Coale, led wildlife monitoring surveys every week throughout the year, except for summer

quarter. For the salmon surveys, Coale was joined by field technicians Lazarus Hart and Sarah Taylor to walk the lower reaches of Japanese and Big Gulch from October 30th to December 28th. Anthropology Lab and field technician Kacie McCarty led water quality monitoring surveys in both gulches throughout the year and produced the correlating data included in this report. Teams of service-learning students from a variety of courses volunteered to go into the field to conduct these surveys. Anthropology Lab and Field Technician, Cali Drake, led computer-lab based activities assessing and uploading photos into eMammal, Smithsonian Institution's open source software tool for collecting, archiving, and sharing camera trapping images and data. Dr. Murphy participated in and/or led several of the surveys and lab activities as well. Skyler Elmstrom managed the geodatabase and produced the maps for the report.

The LEAF School is an environmental anthropology field school based at Edmonds CC that partners with tribes, government agencies, and non-profit organizations in the use of traditional ecological knowledge and anthropological methods to solve modern problems. The LEAF School offers field-based projects for students in anthropology and other service-learning courses in partnership with the Center for Service-Learning at Edmonds CC. These community-based projects are designed to meet needs identified by community partners. This project responds to the needs identified by Snohomish County Airport and the City of Mukilteo for assessments of fish and wildlife habitat in two local tributaries to the Salish Sea (Murphy 2009; Murphy & Oakley 2011). Data gathered by students help assess the effectiveness of a salmon stream restoration project and provide valuable information for effective management of urban green space in areas of strategic cultural and ecological value.

Image 8: L-R: Thomas Murphy, Grace Coale, Bri Castilleja, & Skyler Elmstrom, 10/23/17.

Salmon Monitoring

For the past four years salmon surveys took place four days a week. In the first two years of the study, researchers attempted to go out daily, weather dependent. Concerns about safe access to Japanese Gulch and the impact of surveys on salmon led to a reduction in survey dates per week. In 2018 team leaders and service-learners went out on Fridays and Sundays to Japanese Gulch (for a total of 16 surveys) and Tuesdays and Saturdays at Big Gulch (for a total of 16 surveys). Due to inclement weather and/or hazardous conditions, some surveys had to be rescheduled or cancelled. The students walked beside the stream and in the stream, with the guidance of the team leader to avoid walking in spawning habitat, and examined hiding places to help ensure that they did not miss concealed salmon. They tallied the numbers of salmon observed, identified the species whenever possible, and documented whether they were dead

or alive. When possible the students photographed the salmon. Students and staff conducted necropsies on dead female carcasses using a fillet knife to open the egg cavity. Students recorded the percentages of eggs retained as 0 to 25, 26 to 50, 51 to 75, or 76 to 100 percent. Following the end of each survey, the team leader uploaded photographs, data, and photos to a shared folder on a Google Drive. This Google folder served as a digital repository of field data. Teams recorded total counts of dead and live salmon with their relative location and, when possible, the percentage of egg retention observed in dead female salmon. Dr. Murphy reviewed the data sheets and photos for accuracy and integrity.

Wildlife Monitoring

Advanced students from Dr. Murphy's Human Ecology courses led approximately two to three wildlife surveys per academic quarter beginning in January 2012. Beginning summer 2014 one former student, Grace Coale took over the leadership of all subsequent wildlife surveys in Japanese and Big Gulch and volunteers came from service-learning students who signed up through the Center for Service-Learning at Edmonds CC. In recent years the wildlife surveys led by Grace Coale took place at least once every week during academic quarters (apart from Summer quarter) rotating between four sites in the Mukilteo gulches. During the wildlife surveys, students use photographs and rulers to document track and sign along paths to and from digital, motion-sensitive cameras. Track identification is aided by use of David Moskowitz's *Wildlife of the Pacific Northwest* (2010).[6] Reconnyx PC900, Bushnell Trophy Cam XLT, and Browning Spec Ops BTC-8FHD cameras took three to five photos per motion detection with one to fifteen second intervals. Students inspect the cameras, collect the memory cards, and change the camera batteries during each site check.

The number of cameras at each site has varied from one to two per stream over the course of the seven year data collection period. Occasional human non-staff interference and camera malfunctions have produced data gaps. During the first couple of years of wildlife surveys students in the Human Ecology courses summarized, presented, and published the results of the wildlife surveys for community partners.[7] Starting in 2017 Dr. Murphy, Cali Drake, and Grace Coale led students in the process of uploading current and archived data into the Smithsonian Institute's eMammal database, in partnership with Wildlife Camera Network Northwest.[8] This site enables the sharing of data collected by citizen scientists, making community-based research by community college students accessible to scientists around the world. At least four cameras, two each in the upper and lower sections of each gulch, documented the presence of species throughout the year.

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[6] The tracking abilities of lead faculty and selected staff have been certified through CyberTracker Conservation.Dr. Thomas Murphy and Erin Ryan-Peñuela are certified by CyberTracker Certification at Track & Sign III, Kyle Dewey at Track & Sign II, Chris Shipway and Kerrie Murphy at Track & Sign I in the region of Snoqualmie Valley, WA. David Moskowitz conducted the certification in June 2013. David Moskowitz also certified Dr. Murphy at Track & Sign III in Snoqualmie Pass in January 2016.

[7] See: https://sites.google.com/a/email.edcc.edu/leaf-school-wildlife-monitoring/ and https://edcc.academia.edu/ThomasMurphy/LEAF-School-Posters.

[8] See https://emammal.si.edu/, https://emammal.si.edu/wildlife-camera-network-northwest, and https://emammal.si.edu/leaf-school.

During the salmon spawning seasons of 2017 and 2018, the researchers directed wildlife monitoring efforts towards the relationship between salmon and urban wildlife. Using track identification and motion activated cameras, students documented species in and around the salmon bearing areas of the stream. Whenever possible, Grace Coale, as the team leader, directed the cameras towards salmon carcasses.

Water Quality Monitoring

A pilot of monthly monitoring of water quality according to the Global Water Watch Protocol began in August 2015. Although a severe windstorm hampered the initial effort, regular monthly monitoring of all parameters (pH, dissolved oxygen, alkalinity, hardness, bacteria and turbidity) began in September 2015 and has continued through December 2018, under the leadership of Kacie McCarty. Annual collection of macroinvertebrate data began in May 2016.[9]

GIS Methods

Geospatial products developed for this project include data and imagery from Snohomish County Public Works, City of Mukilteo, and the United States Geological Survey (USGS) (see GIS Sources in the Bibliography). In order to assess the geographic trends of fish and wildlife and provide usable data for the project geodatabase, each survey procedure incorporates the collection of location information. Locations are collected during surveys using handheld Garmin or Trimble GPS units and/or mobile devices with the GeoTracker application (created by Ilya Bogdanovich).

The primary means of manipulating GIS data for this report is ESRI's ArcGIS® version 10.6.1 and Microsoft® Excel. Overviews of each site may contain pan-sharpened images that consist of LiDAR hillshades and multispectral aerial photography. Vector data overlays are products of geoprocessing to exclude irrelevant portions of datasets and products of the project GPS data post-processing and locally-produced spreadsheets. Due to limitations in GPS equipment, the data displayed in the maps below may be inaccurate by up to ±10 meters.[10]

Results

Data collected from 2012 through 2018 demonstrate consistent use of Big and Japanese Gulch by salmon and wildlife. During the most recent year surveyors recorded coho in both Japanese and Big Gulch and found more evidence of pre-spawn mortality in Big Gulch. In stark contrast to 2017's record numbers of chum salmon, researchers only documented one chum salmon in Big Gulch this year. Geographic data enabled identifications of hotspots in each stream. Water quality data indicate Japanese Gulch is generally habitable but Big Gulch is less hospitable.

[9] Teams collected data from Big Gulch at approximately N 47.90969° W 122.31706° and from Japanese Gulch at approximately N 47.94295° W 122.28933°. Additional details about chemical, bacteriological, and biological sampling methods appear in Appendix A.

[10] Additional GIS data created by the LEAF School for this project is available upon request.

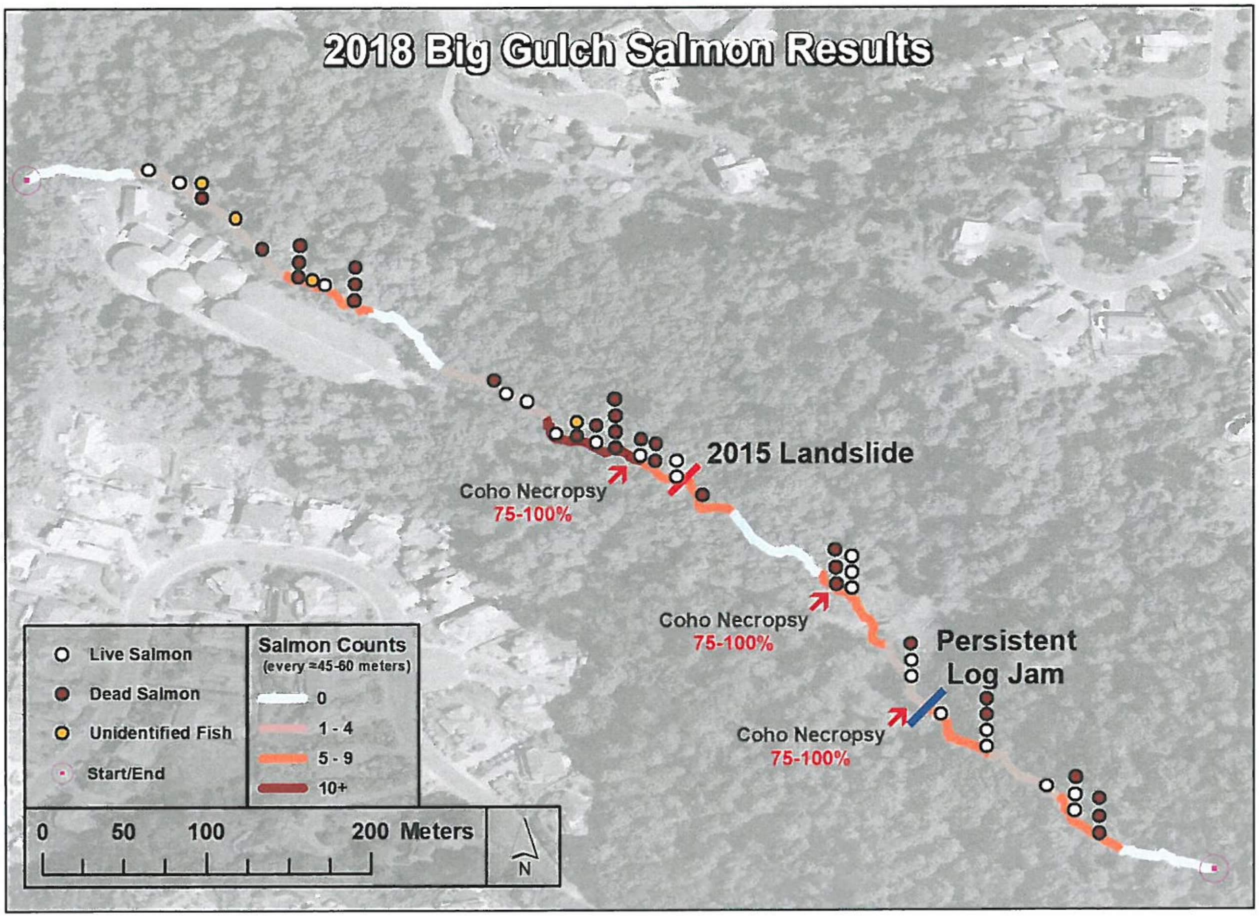


Figure 7: Big Gulch salmon survey results. The geographic data show a spatial join of locations of observed salmon with 15 split stream sections. The salmon are summed for each section and color coded, ranging from low to high; blue to red. Salmon and fish locations are stacked vertically for visibility if observation locations overlapped. Female egg retention is shown in red text for each necropsy performed.

Big Gulch Salmon Monitoring

Salmon monitoring in 2018 at Big Gulch began on Oct. 30th and continued through December 27th. Cumulatively, surveyors recorded 24 live salmon sightings and 34 dead salmon over the course of the season.[11] The most salmon documented during a single survey at Big Gulch occurred at on November 3rd, with 1 live chum, 9 live coho and 1 live unidentified. These numbers are significantly lower than last year's findings of 925 live fish and 132 dead coho cumulatively over the season. Of the three necropsies performed on deceased female coho salmon, all three retained eggs after death, all in the 75-100 percent retention range. Salmon observations extended from the base of the sewage treatment plant to the end of the survey. Salmon concentrated in reaches alongside the treatment plant, just below the 2015 landslide, and above the bridge and persistent log jam (Fig. 7).

[11] These numbers are not a total count of salmon in the stream over the season. They indicate sightings of fish collected twice per week per stream.. Fish that stayed in the stream for a full week would have been counted twice. Fish who spent less than a few days in the stream or successfully eluded researchers would not be included in these numbers.

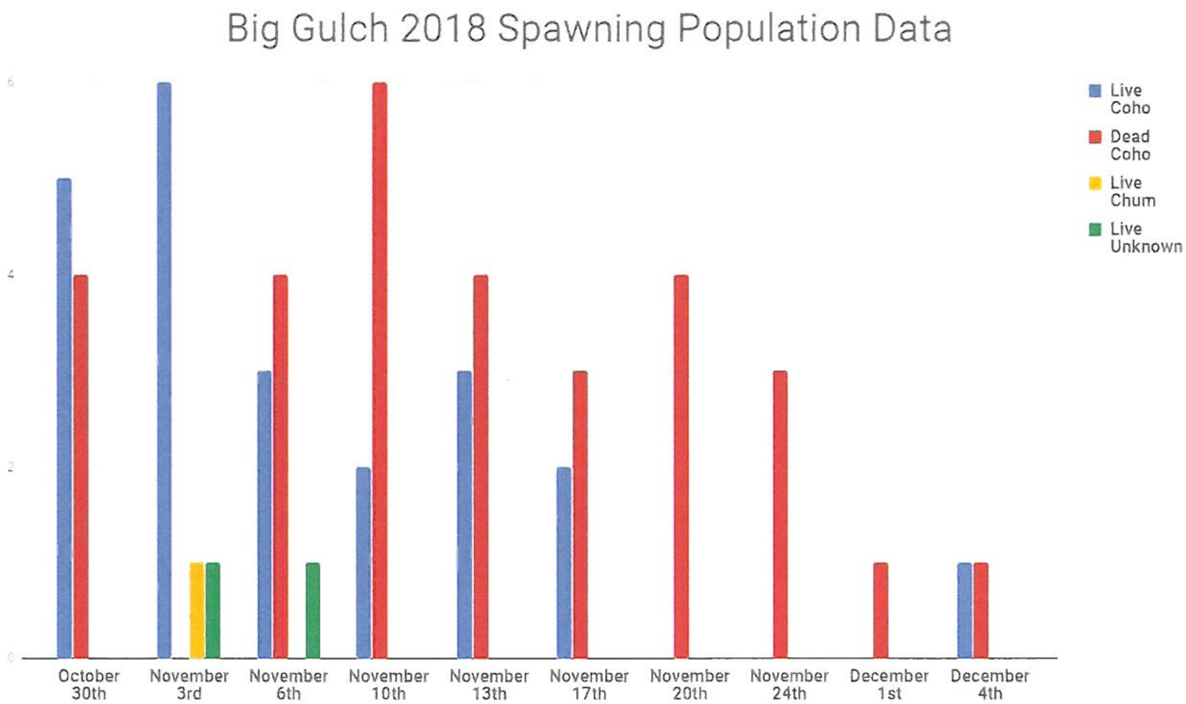


Figure 8: Salmon survey results in Big Gulch, 2018.

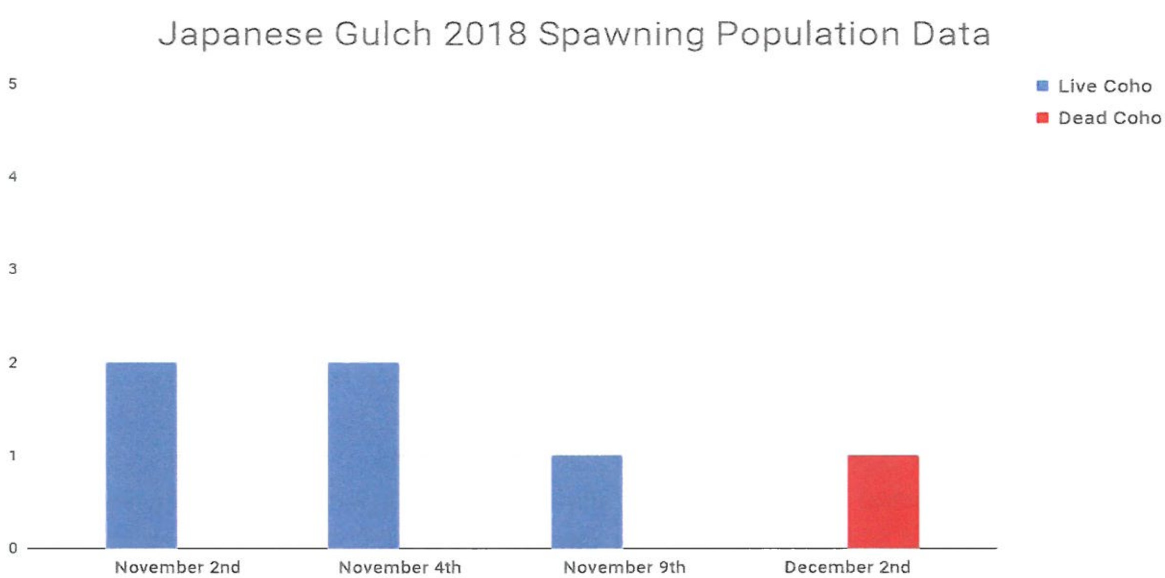
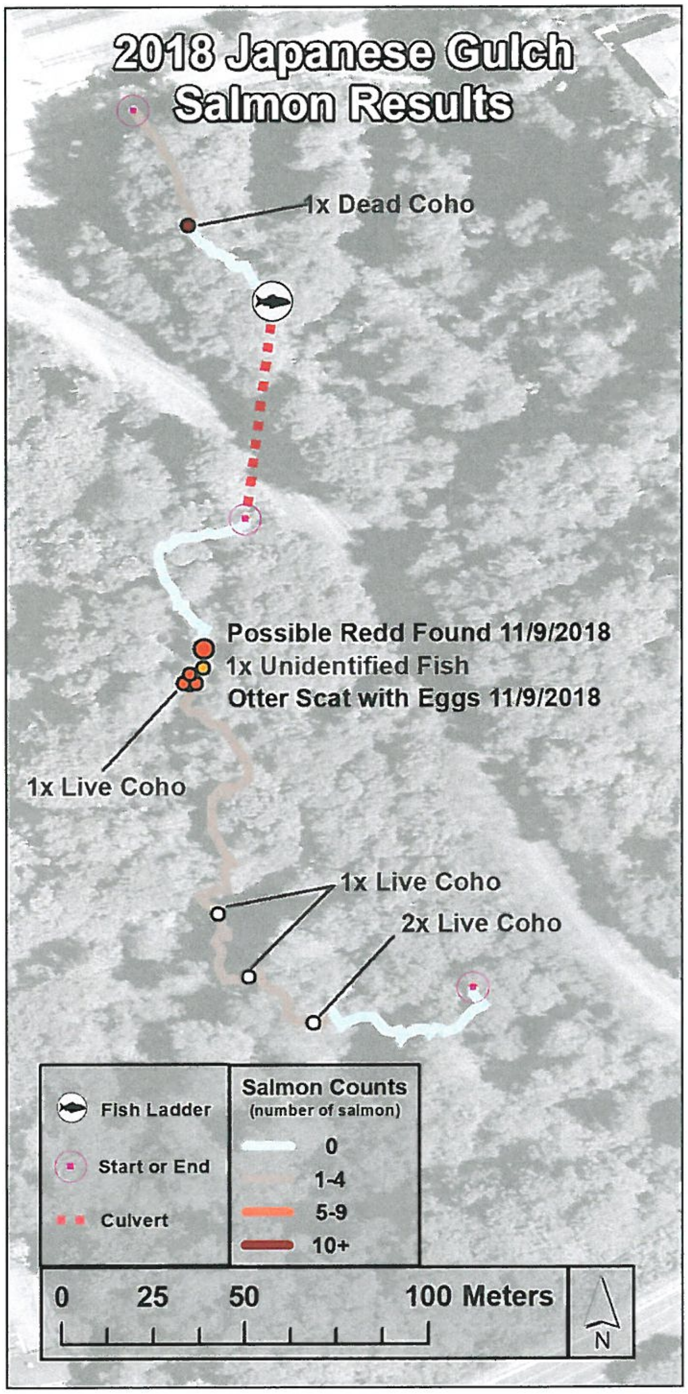


Figure 9: Salmon survey results in Japanese Gulch, 2018

Japanese Gulch Salmon Monitoring



Salmon monitoring at Japanese Gulch this year began on October 30 and continued through December 28, 2018. Observers documented a cumulative 5 live sightings and 1 dead fish in Japanese Gulch. Only coho appeared in the stream this season.

The majority of the salmon appeared in the middle sections of the upper reach of the stream above the first culvert under the Boeing railroad spur and just below the second culvert (Fig. 10). This upper reach includes the section of the stream restored to its historic chanel and remains a preferred spawning habitat. Its long term viability for spawning is substantially compromised by an aggressive invasion of bittersweet nightshade.

Cumulative & Comparative Results

Figure 11 shows numbers of coho, chum and unidentified fish along with necropsies, and pre-spawn mortality events over the past six years.[12] 2014, 2015 and 2018 data show relatively modest runs of chum and coho in Big Gulch while chum runs in 2017 appear significantly robust in contrast. The remaining numbers in both streams are particularly low. The collective data show some variability and inconsistency, particularly in the Big Gulch runs, yet they

Figure 10: GIS map of Japanese Gulch salmon survey results. Geographic data in the figure shows a spatial join of locations of observed salmon with 15 split stream sections. The salmon are summed for each section and color coded, ranging from low to high; blue to red.

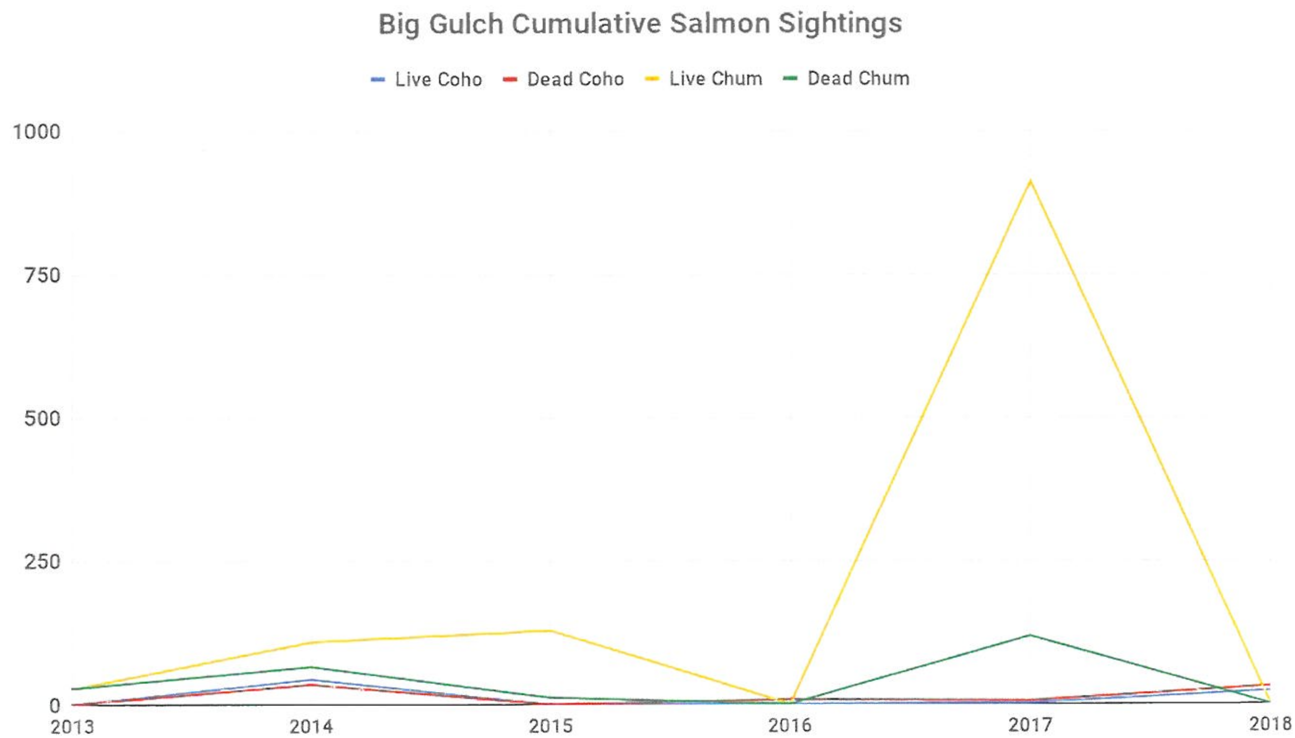
[12] The observations of coho in 2012 are not included because they occured only a couple of occasions and no effort was made to survey the full season. Limited access to Japanese Gulch and the cost of surveying resulted in a shift from daily surveys alternating between streams to just two surveys each week per stream starting in 2015. This shift in protocol explains the reduction in numbers of survey dates in the table. The upward and downward trends in sightings per survey and highest one-day sightings, though, mostly correlate with those evident in total number of sightings.

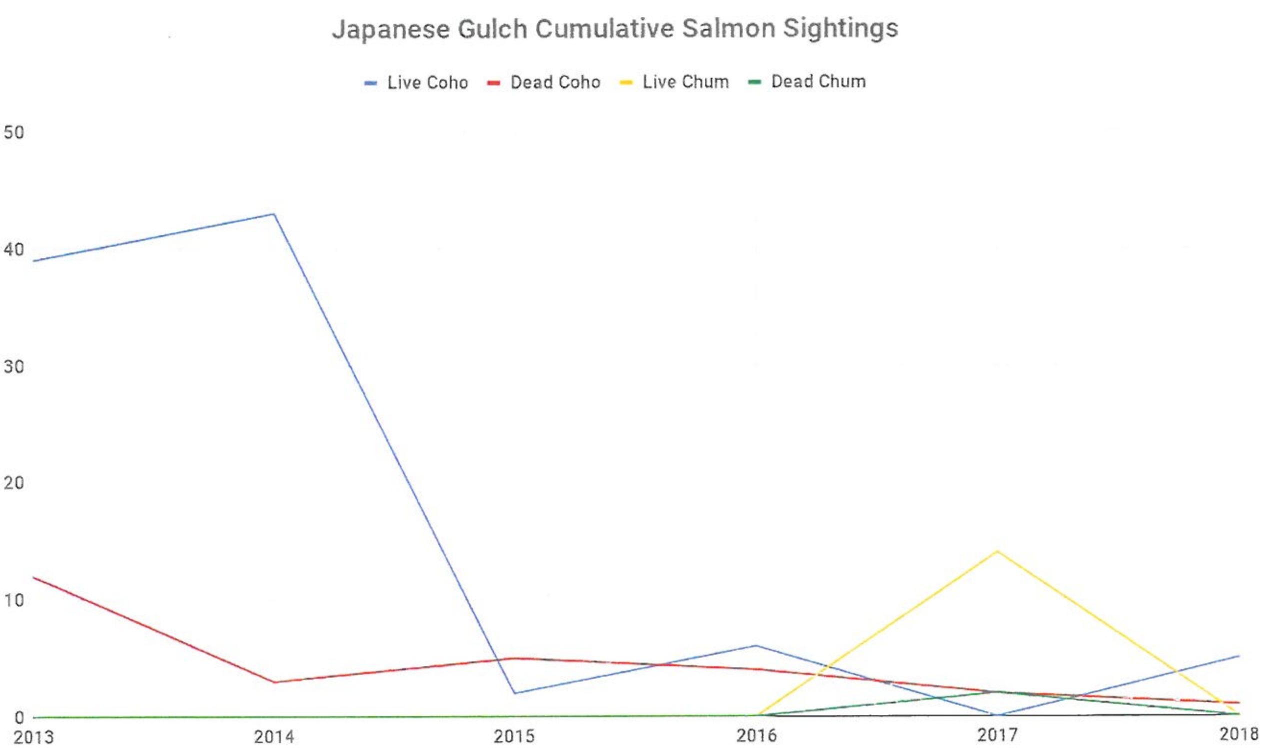
also show at least some salmon returning to each stream every year surveyed.

Survey Site	Japanese Gulch						Big Gulch					
Survey Year	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Total Survey Dates	22	29	15	15	15	16	22	29	15	13	16	16
Total Sightings	63	46	7	24	22	6	58	268	148	8	1057	58
Coho, Alive	39	43	2	6	0	5	0	44	0	0	2	23
Coho, Deceased	12	3	5	4	2	1	0	35	0	8	6	31
Chum, Alive	0	0	0	0	14	0	27	109	129	0	912	1
Chum, Deceased	0	0	0	0	2	0	28	66	12	0	119	0
Coho Necropsies	n/a	0	2	3	0	0	n/a	1	0	1	3	3
Coho PS Mortality*	n/a	n/a	0	2	n/a	n/a	n/a	1	n/a	0	3	3
Chum Necropsies	n/a	0	0	0	0	0	n/a	0	6	0	6	0
Chum PS Mortality*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0	n/a	3	n/a
Unidentified	12	0	n/a	14	2	0	3	14	7	0	15	2
Highest One-day	7	8	2	3	5	2	7	26	33	5	297	11

*Figure 11: Comparative data from 2103 - 2018. *PS = pre-spawn mortality..*

Given the small sample sizes, the percentages of coho pre-spawn mortality over five years (no pre-spawn mortality data collected in 2013) range from 0 to 100% per year and thus may not be particularly informative when considered on an annual basis. Over the five years, though, an average chum pre-spawn mortality of 25% and a collective average of coho pre-spawn mortality of 69.2% across both streams may be more informative. No chum necropsies have been possible yet in Japanese Gulch, so the rate of 25 percent chum pre-spawn mortality is only applicable to Big Gulch. The coho pre-spawn mortality rate of 40% for Japanese Gulch alone remains the same as previously reported with no new data in 2017 or 2018. In Big Gulch, however three new necropsies, all demonstrating pre-spawn mortality in each of the last two years, resulted in a big increase from 50 to 87.5% in the average of pre-spawn mortality over the span of five years of data collection.





Figures 12 & 13: Cumulative salmon sightings in Big and Japanese Gulch, 2013-2018.

Big Gulch Wildlife Monitoring

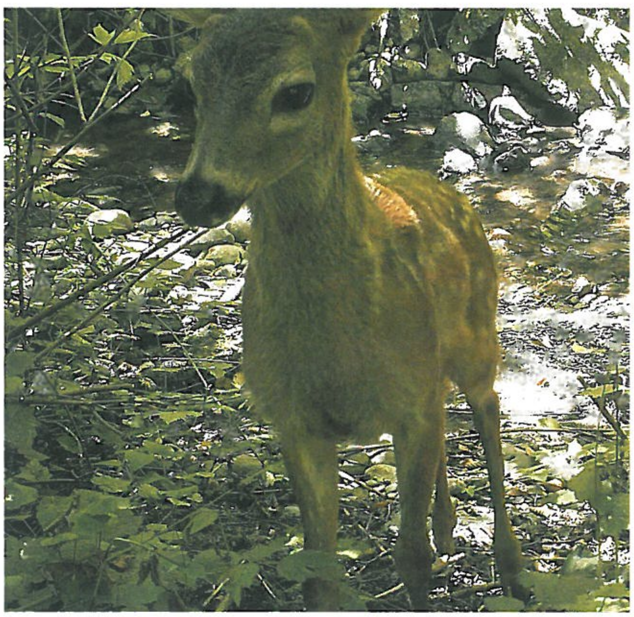


Image 9: Top left- Bald eagle scavenging coho carcass. 12/20/18 *Image 10: Top right- River otter near salmon carcass. 1/19/18*

Image 11: Bottom left- Juvenile black-tailed deer (male). 7/25/18 *Image 12: Bottom right- Coyote scavenging coho carcass. 12/24/18*

In response to a request from the City of Mukilteo service-learning students from Edmonds CC began monitoring wildlife at Big Gulch in January of 2012. No existing list of wildlife at Big Gulch could be found at that time so researchers compiled one based upon camera traps and wildlife tracking data and began publishing it with annual reports in 2014.[13] In 2017 service-learners began uploading camera trap images to the Smithsonian Institute's citizen science collaborative

[13] Skagit River System Cooperative published a list of fish documented through electrofishing (Beemer, et al. 2013).

database known as eMammal to make data more readily available to other interested researchers. After six years of camera traps, tracking, and observations this list contains 15 species of mammals, 19 species of birds, and one each of amphibians and reptiles (Appendix B). These observations confirmed seven species of mammal and birds recorded in field notes from the 1990s recently obtained from Jake Jacobson of Saltwater Anglers of Mukilteo. The species most commonly documented with the wildlife cameras include eastern gray squirrel (*Sciurus carolinensis*), black-tailed or mule deer (*Odocoileus hemionus columbianus*), northern raccoon (*Procyon lotor*), mountain beaver (*Aplodontia rufa*), and coyote (*Canis latrans*). Additional species of interest documented by the students include flying squirrel (*Glaucomys sp?*), Douglas's squirrel (*Tamaiasciurus douglasii*), and California quail (*Callipepia californica*).

During 2018 observers primarily found river otter (*Lontra canadensis*), raccoon (*Procyon lotor*), black-tailed deer (*Odocoileus hemionus columbianus*), coyote (*Canis latrans*), and eastern gray squirrel (*Sciurus carolinensis)* through both tracks and camera traps. Coyote pups photographed this year appear to be the youngest yet recorded in Big Gulch. Researchers documented a well used river otter latrine in the upper reach of the salmon spawning range. A remote camera near the lower reaches of the gulch recorded a series of incredible photos of coyote predation of a mountain beaver, whose abundant burrows suggest they may be a readily available food source in the area.

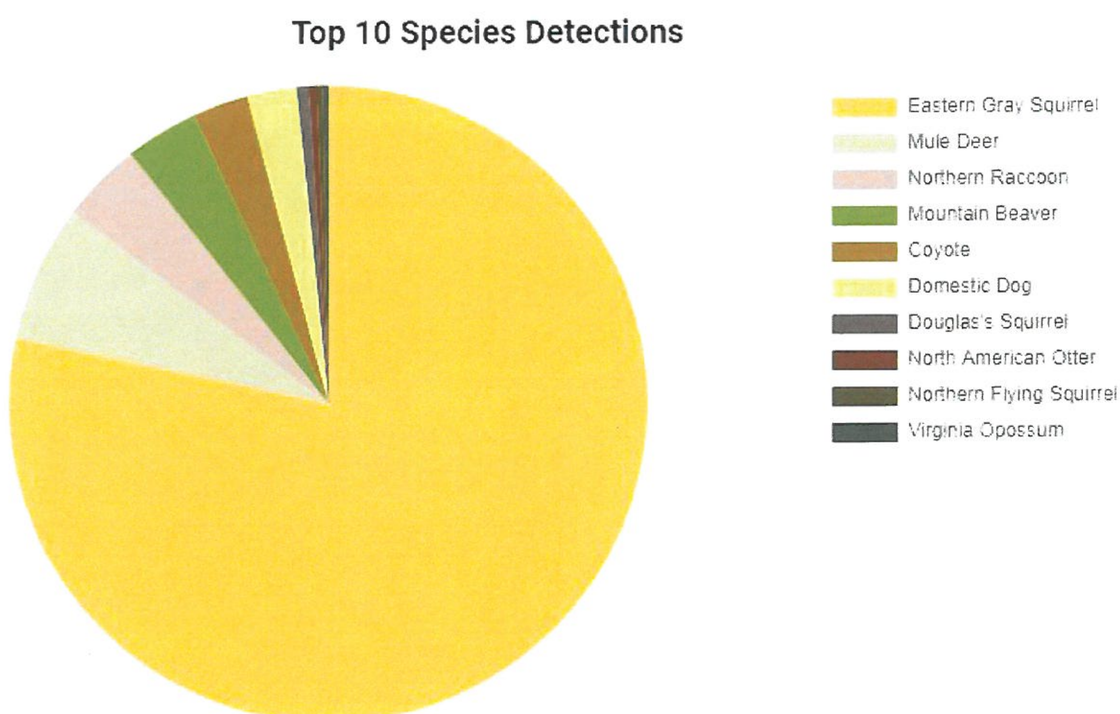


Figure 14: Cumulative camera detections in Big Gulch, by species, 2012-2018. Courtesy of eMammal, Smithsonian Institution.

The placement of wildlife cameras facing dead salmon carcasses during the 2017 and 2018 salmon monitoring season permitted the collection of data about wildlife and salmon interactions. In Big Gulch, juvenile and adult bald eagles, along with two instances of coyote, scavenged a chum carcass and were captured on camera (images 9 and 12). The cameras documented multiple instances of great blue heron (*Ardea herodias*) showing interest in the live salmon, following them as they swam upstream. However, no evidence of actual predation on salmon by great blue heron appeared in the photos. As documented via track and sign, river otter, and raccoon appear to be the most frequent scavengers of salmon carcasses. *See appendix B for a full list of fish and wildlife species documented.*

Japanese Gulch Wildlife Monitoring

Image 13: Top left- Flying Squirrel 6/8/18
Image 14: Top right- Otter scat containing salmon eggs 11/9/18
Image 15: Bottom left- Coyote fleeing domestic dog . 2/9/18
Image 16: Bottom right- Golden-Crowned Sparrow 12/18/18

Wildlife monitoring at Japanese Gulch also began in January of 2012 at the request of the City of Mukilteo. Mukilteo Wildlife Society already maintained a robust list of wildlife their members had observed in Japanese Gulch to which students have been able to add American shrew mole *(Neurotrichus gibbsii)*, black bear (*Ursus americanus*), river otter *(Lontra canadensis)*, bufflehead *(Bucephala albeola)*, green-winged teal *(Anas carolinensis)*, hooded merganser (*Lophodytes cucullatus*), and northern red-legged frog *(Rana aurora)*. Students have confirmed an additional 13 mammals and 22 birds previously recorded by Mukilteo Wildlife Society.

Monitoring of the Japanese Gulch riparian zone in 2018 added added golden-crowned sparrow (*Zonotrichia atricapilla*) and American dipper (*Cinclus mexicanus)* to this ongoing list. Regular sightings of coyote (*Canis latrans)*, barred owl *(Strix varia)*, raccoon *(Procyon lotor)*, and eastern cottontail *(Sylvilagus floridanus)* continued. Surveyors found salmon eggs within river otter scat early in the survey season, suggesting either salmon predation or unearthing redds by river otter. The increasingly frequent instances of black bear (*Ursus americanus)* and flying squirrel (*Glaucomys sp?*) observed last year continued this year. Trackers documented additional black bear scat in the greater Japanese Gulch area. A motion activated trail camera captured a video of coyote *(Canis latrans)* attempting predation on mallard *(Anas platyrhynchos)* and green-winged teal (*Anas carolinensis)* in upper Japanese Gulch. Interaction between domestic dog and coyote also appeared on camera in Japanese Gulch (Image 15).

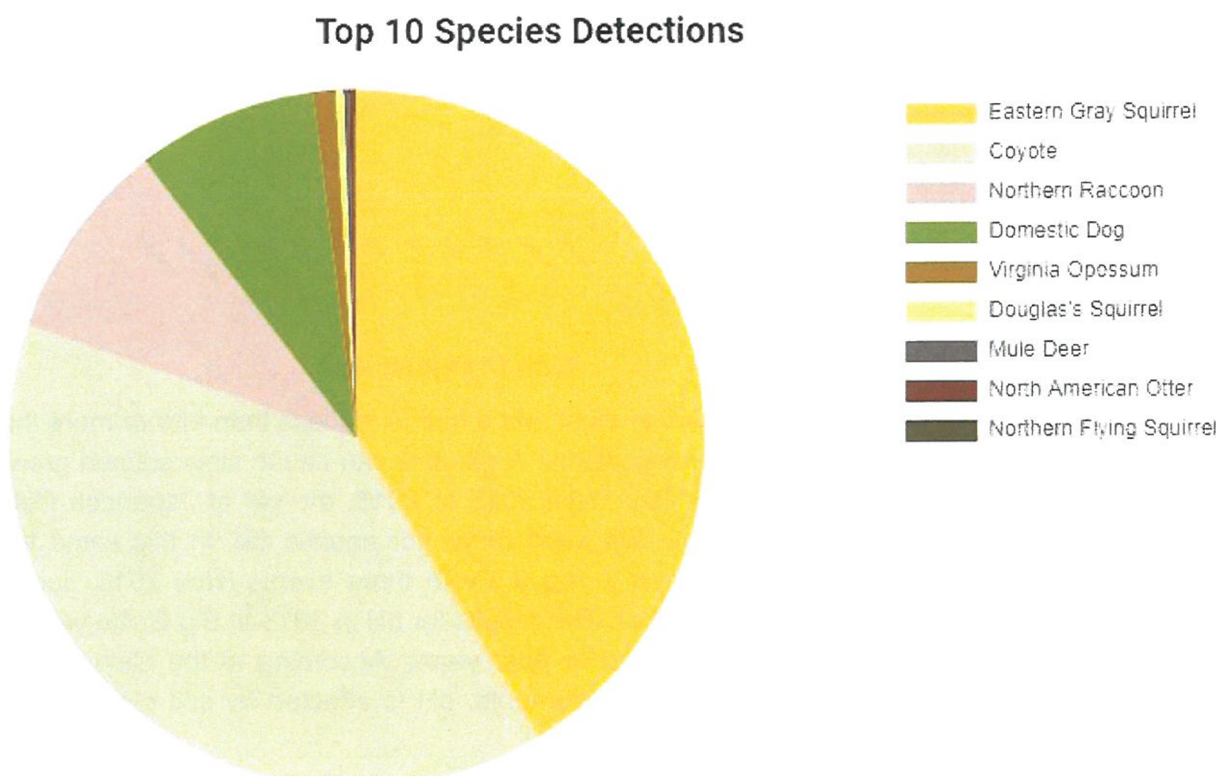


Figure 15: Cumulative camera detections in Japanese Gulch, by species, 2012-2018. Courtesy of eMammal, Smithsonian Institution.

At the request of the City of Mukilteo, researchers placed wildlife cameras much higher in the watershed, near the Japanese Gulch South Trailhead in 2017. There they documented a high concentration of eastern grey squirrel, coyote, barred owl, racoon, and several woodpecker species. One camera location captured a flying squirrel using the same tree nearly every night around 2 am, often carrying some unidentifiable quarry. Because of their overlapping ranges in this region, any flying squirrels documented at this site could be either northern flying squirrel or the newly identified cryptic species, Humboldt's flying squirrel (Morell et al. 2017).

Water Quality Monitoring

Regular monthly monitoring of a variety of water quality parameters (pH, dissolved oxygen, alkalinity, hardness, bacteria and turbidity) began in August or September 2015 and followed Global Water Watch protocols.[14] Researchers began collecting macroinvertebrate data in May of 2016 and annually after that. Staff availability, especially in 2018, resulted in some data gaps. Data gaps are indicated in graphs below by missing lines or just a point and no line when sequential monthly data is not available.

pH

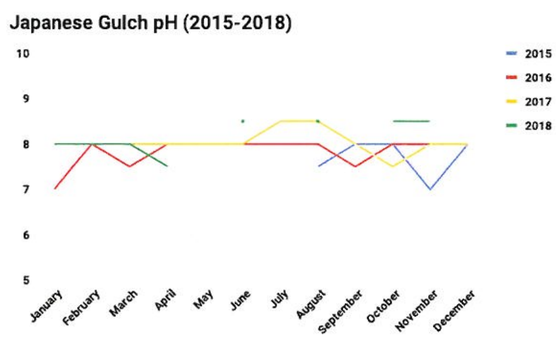


Figure 16: pH in Japanese Gulch

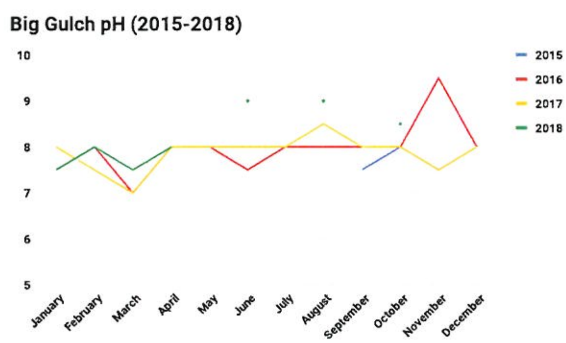


Figure 17: pH in Big Gulch

The optimal pH range for aquatic life is six to eight and a half. A pH less than four or more than eleven is usually lethal to fish and other organisms. A pH of 9 can cause slow salmon growth and limit reproduction (Deutsch, et al, 2010). From 2015 to 2018, the pH at Japanese Gulch ranged between 7 and 8.5 and fell within the ideal range for aquatic life. In this same time frame, the pH at Big Gulch ranged between 7 and 9.5 with three events (Nov 2016, June & August 2018) in the danger zone of 9 or higher. The results for pH in 2018 at Big Gulch were on average slightly more basic than pH collected in past years. According to the Global Water Watch protocol the pH was measured in 0.5 increments. pH is affected by soil pH, acid rain, industrial and agriculture waters (Deutsch, et al, 2010).

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[14] Dr. Thomas Murphy and Kacie McCarty received water quality certification from Alabama Water Watch in 2015 for implementation of Global Water Watch protocols.

Hardness

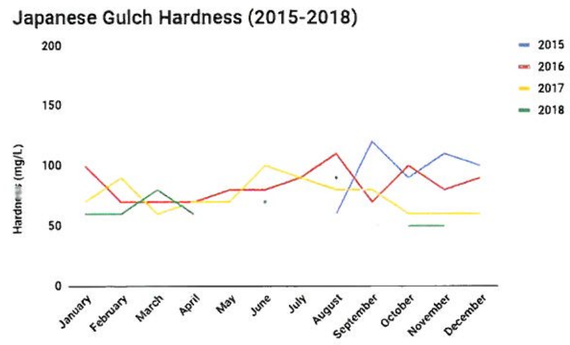

Figure 18: Hardness in Japanese Gulch

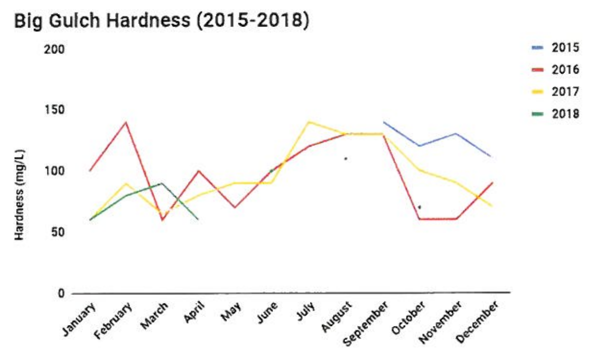

Figure 19: Hardness in Big Gulch

Hardness is primarily the concentration of calcium and magnesium ions in water. Most fish and aquatic organisms live in waters with hardness between fifteen and 200 mg/L. Fish reproduction may be limited in waters with hardness less than fifteen mg/L or greater than 200 mg/L (Deutsch, et al, 2010). From 2015 through 2018 the hardness at Japanese Gulch ranged between 50 and 120 mg/L and stayed within optimum concentrations for aquatic life. In this same time frame the hardness at Big Gulch ranged between 60 and 140 mg/L also stayed well within optimum concentrations for aquatic life. The error is +/- 20 mg/L for all hardness data entries.

Alkalinity

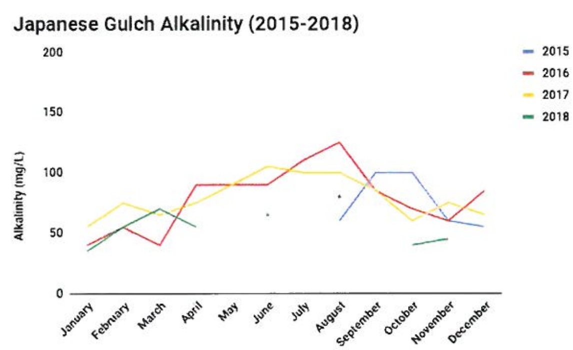

Figure 20: Alkalinity in Japanese Gulch

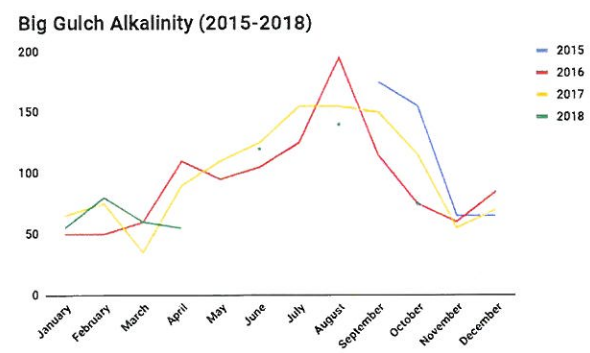

Figure 21: Alkalinity in Big Gulch

Alkalinity is a measure of the buffering capacity of water. Higher alkalinity provides a buffer against changes in pH, making it more stable for aquatic life. If a waterbody has low alkalinity, it is susceptible to rapid changes in pH (Deutsch, et al, 2010). The Mukilteo streams tend to have lower alkalinity during months of higher stream flows such as those brought on by fall and winter rain events. From 2015 to 2018 the alkalinity at Japanese Gulch ranged between 45 and 125 mg/L. During this same time frame the alkalinity at Big Gulch ranged more dramatically between 35 and 195 mg/L. The error is +/- 20 mg/L for all alkalinity data entries.

Dissolved Oxygen

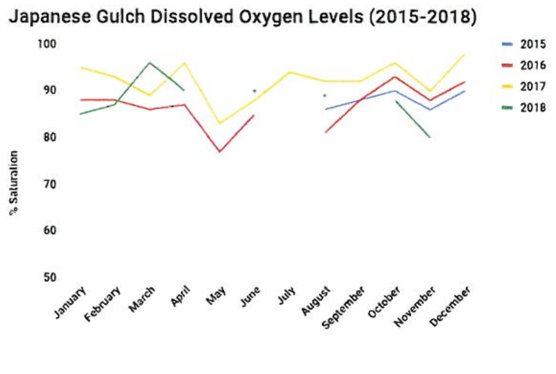

Figure 22: Dissolved oxygen in Japanese Gulch

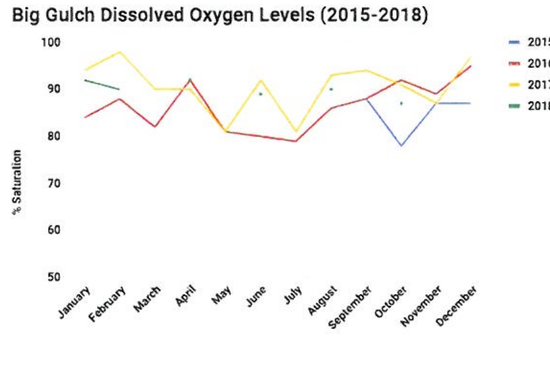

Figure 23: Dissolved oxygen in Big Gulch

A dissolved oxygen (DO) level of at least 5.0 ppm is desirable for most aquatic organisms. Water that is supersaturated with DO usually has unnaturally high levels of phosphorus or nitrogen from fertilizer or animal waste. A DO that is too high (more than 125% DO saturation) can be dangerous to fish (Deutsch, et al., 2015). The student experiments yielded dissolved oxygen levels in ppm that they converted to % DO saturation levels based on a water temperature and solubility conversion factor (West Virginia Department of Environmental Protection 2017).

From 2015 through 2018 average DO readings at Japanese Gulch ranged between 8 and 13 ppm (82-100% saturation). In the same time frame at Big Gulch average dissolved oxygen reading for each month ranged between 8 and 12.6 ppm (87-98% DO saturation). The margin of error for each reading is 0.6 ppm. At both sites, the dissolved oxygen levels fall within the desirable range of dissolved oxygen for aquatic life.

Turbidity

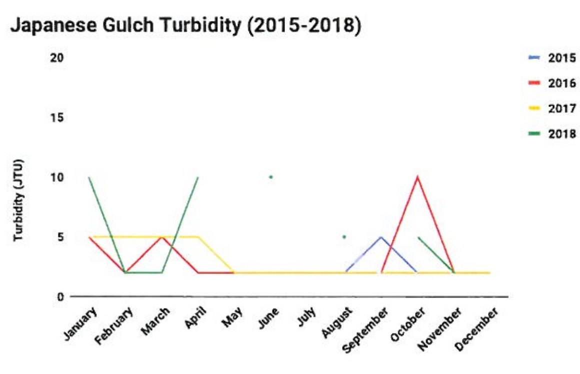

Figure 24: Turbidity in Japanese Gulch

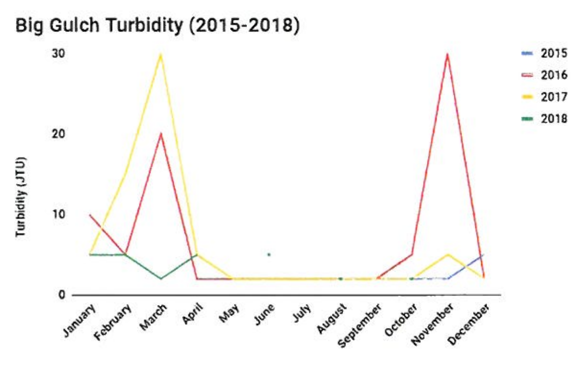

Figure 25: Turbidity in Big Gulch

Turbidity is a measurement of water cloudiness caused by suspended matter. High turbidity limits sunlight penetration in water, inhibits growth of aquatic plants, and can upset aquatic

ecosystems. If one addition of Standard Turbidity reagent surpassed the turbidity of the stream water, the result was recorded as 2 JTU. If two additions of Standard Turbidity reagent surpassed the turbidity of the stream, the result was recorded at 5 JTU. Turbidity greater than 25 JTU cannot be measured using the Alabama Water Watchers kit (Myre, 2006). Therefore, results that were too high to measure (greater than 25 JTU) are assigned the next higher value of 30 JTU in the graphs above. The error for each measurement is +/-5 JTU. Results with higher JTU values were also evaluated using Nephelometric Turbidity Units (NTU) whenever possible.

From 2015 to 2018 the turbidity at Japanese Gulch ranged from 2 to 10 JTU with the most recent high values occurring in January, April and June 2018. In January and June 2018 the results were less than 8 NTU. In April 2018 the second measurement resulted in 13 NTU. At Big Gulch, the turbidity ranged between 2 and 30 JTU with the spikes in November of 2016 and March of 2017. A second measurement of turbidity in November 2017 yielded 30 NTU. This high turbidity event co-occurred with high pH, low alkalinity readings, and a heavy storm-induced stream flow.

E. coli

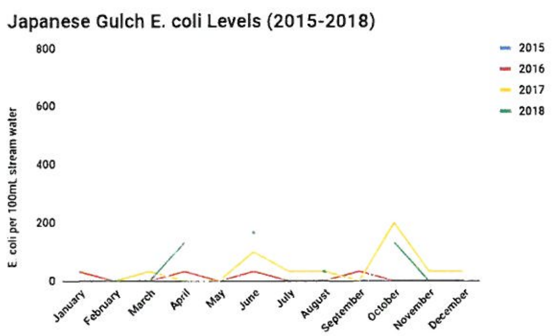

Figure 25: Fecal coliform in Japanese Gulch

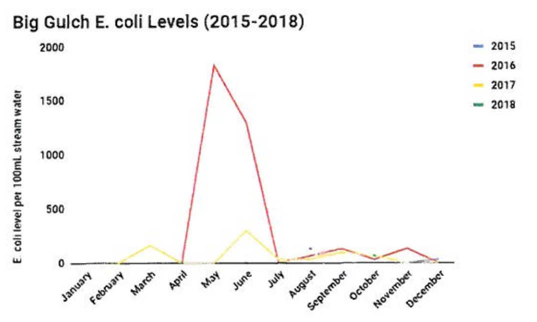

Figure 26: Fecal coliform in Big Gulch

Measurements of *E. coli* allow an estimation of the amount of fecal matter in the water. Levels under 200 *E. coli* colonies per 100mL are considered safe for human recreation. Levels between 200 and 600 are considered safe for contact but unsafe for recreation such as swimming where water may be accidently swallowed. Levels of *E. coli* over 800 per 100mL are considered unsafe for human contact. Data was collected at most on one occasion per month per site and daily variation is unknown.

At Japanese Gulch *E. coli* levels from 2015 through 2018 ranged between 0 and 200 *E. coli* per 100mL stream water. The *E. coli* levels only reached unsafe conditions in October of 2017. *E. coli* levels at Big Gulch have varied more dramatically over the same time frame. Between September 2015 and April 2016 the *E. coli* level at Big Gulch were at a level considered safe (fewer than 200 *E. coli* per 100mL). However in May 2016 the level of *E. coli* increased drastically to 1830 *E. coli* per 100mL. Levels over 800 *E. coli* per 100mL are considered unsafe for human contact recreation. The *E. coli* level remained at a very high level in June (1300 per

100mL) but went down to zero again in July and remained within the safe range for the remainder of the the year 2016 (fewer than 200 *E. coli*/100mL). In 2017 the highest value observed was 300 *E. coli* per 100mL in June 2017, indicating that at times during the summer the water quality appears unsafe for recreational activities. All other test dates throughout the year 2017 had *E. coli* levels with fewer than 200 *E. coli* per 100mL. In 2018 the *E. coli* levels ranged between 0 and 133 *E. coli* per 100mL stream water, with zero E. coli found on the testing dates in January, February, April and June. In 2018 Big Gulch was in the Global Water Watch safe range and relatively free of fecal contamination.

Macroinvertebrates

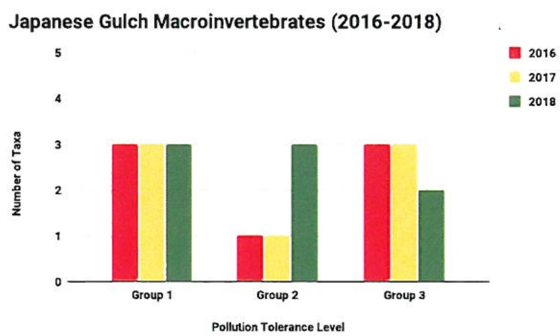

Figure 28: Macroinvertebrates in Japanese Gulch

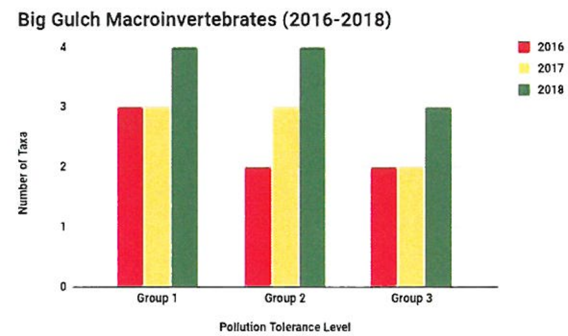

Figure 29: Macroinvertebrates in Big Gulch

Macroinvertebrates are the "little bugs" that live in the stream between several months and multiple years of their life span. For this reason they can indicate the long term health of a stream. In Global Water Watch protocols Group 1 macroinvertebrates are the most sensitive to pollution. An abundance of Group 1 species can indicate a very healthy stream. Group 2 macroinvertebrates have intermediate sensitivity to pollution. Group 3 macroinvertebrates can live in very polluted water. A relative abundance of Group 3 macroinvertebrates can indicate that a stream is polluted.

At Japanese Gulch during annual assessments each May from 2016 to 2018 service-learners found three Group 1 indicators (caddisfly, mayfly, stonefly). In 2016 and 2017 they found one Group 2 indicator (scud) and two (black fly and filtering caddisfly) in 2018. In 2016 and 2017 they found three Group 3 indicators (aquatic worm, midge, leech) but only two (aquatic worm and midge) in 2018. The first two years of data collection the stream at Japanese Gulch had biotic index of 14 and rated as "fair." The overall biotic index rating in 2018 was 17 and the stream health rated as "good."

At Big Gulch in 2016 and 2017 data collectors recorded three Group 1 indicators (caddisfly, mayfly, stonefly). In 2018 they found an additional Group 1 indicator (snails). In 2016 the students identified two Group 2 indicator (blackfly, scud). In 2017 they found an additional Group 2 indicator (crane fly) and yet another in 2018 (filtering caddisfly). Two Group 3 indicators (aquatic worm, midge) appeared each year, with an additional one (leech) in 2018. During the

first two years of data collection a biotic index of 15 indicated Big Gulch's stream health as "fair," improving to 23 in 2018, earning a rating of "excellent" stream health according to the Global Water Watch rating system for macroinvertebrate data.[15]

Discussion

Data collected from 2012 - 2018 demonstrate that Japanese and Big Gulch contain valuable habitat for supporting fish and wildlife in the heart and edges of the City of Mukilteo and downstream from Snohomish County Airport. Seven years of monitoring in these urban Puget Sound tributaries show generally low numbers for coho in each stream as well as inconsistent and highly variable returns of chum. A variety of wildlife utilize the riparian zones of these urban streams. Habitat restoration exemplified by the removal of barriers to fish passage in Japanese Gulch is having a positive impact on the ability of salmon to spawn in newly accessible portions of the stream but the long-term viability of these salmon runs may require more comprehensive approaches that lessen the threats posed by stormwater runoff from impervious roads, pre-spawn mortality, and habitat degradation by invasive species. Conscientious management by municipal officials is needed to balance the needs of fish, wildlife, and humans.

Higher than expected rates of pre-spawn mortality among both chum and coho are particularly concerning. While low sample sizes may undermine comparability of the data, rates of 40% coho pre-spawn mortality in Japanese Gulch over a five year period are slightly above the rate of 32.57% predicted in models generated in a recent study by scientists at NOAA (Fiest, et al. 2017). 100% pre-spawn mortality documented in three necropsies of coho at Big Gulch in 2017 and 2018, pushed the average pre-spawn mortality rate over the survey period as high as 87.5%. This number is substantially higher than the predicted rate of 33.09% (Fiest, et al. 2017; see also Figure 4 in this report).

A jump in the rate of chum pre-spawn mortality from 0 to 25% is also surprising. A 2006 analysis of Seattle's Pipers Creek with similarly overlapping runs of coho and chum resulted in 100% of the coho mortality before spawning while the egg retention rate for chum carcasses was only 4% (Scholz, et al. 2011, 6). Similarly, in controlled experiments exposing both chum and coho to stormwater runoff, contaminants "are the likely cause of the disruption of ion balance and pH in coho but not in chum salmon" (McIntyre, et al. 2018, 196). Small sample sizes for our necropsies suggest caution should be taken in interpreting these results but they do appear much higher than would be expected given results elsewhere in the Puget Sound region. The increased competition among spawners in 2017 as well as the stress resulting from surveyors in the stream may be important factors.[16]

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[15] Students also documented alderflies and water mites in 2017 as well as planarians in both of the last two years. None of these macroinvertebrates, however, are used in the Global Water Watch rating system.

[16] It appears to our team that our presence in the stream may add undue stress on the fish that could be contributing to these higher mortality figures. The development of less invasive survey methods in future years might help but they could also make future data less accurate and of less value comparatively.

The particularly high rates of salmon mortality prior to spawning in Big Gulch appear alongside erratic and concerning water quality data. The pH levels in this stream measured in the danger zone of 9 or higher three different times over a four year period.[17] Alkalinity, a measurement of the buffering capacity of the water, varied more widely in Big Gulch than in Japanese Gulch. Turbidity also spiked into danger zones during three measurements in Big Gulch, one of which coincided with a spike in pH. Big Gulch also suffered from a spike in fecal coliform in the spring of 2016, the likely source of which was identified and corrected by staff at the City of Mukilteo. While more favorable assessments of water quality come from dissolved oxygen, hardness, and macroinvertebrates; measurements in Big Gulch were more variable than Japanese Gulch in all categories except dissolved oxygen. These water quality assessments suggest some problematic pollutants are entering the Big Gulch stream. Yet, these parameters may only indirectly measure the likely culprit for the coho die-offs, excessive stormwater runoff with toxic chemicals coming from roads, possibly the particles wearing from tire wear (Fiest, et al. 2017, 2; Peter, et al. 2018; Scholz, et al. 2011; Spromberg, et al. 2014 & 2016).

Addressing pre-spawn mortality requires basin-wide approaches that reduce stormwater pollution and moderate flows. High flow events in Big Gulch may be exacerbated by impervious surface in the upper watershed and the long, straight, chute-like features of the stream in the lower reach where the concrete wall supports the wastewater treatment plant on the south side. These high flows, combined with scouring, turbidity, and siltation appear to be damaging salmon redds and may be contributing to inconsistent runs. Observations of eggs flowing out to the Puget Sound during multiple years of the project could be a result of these high flooding events. Scour to the depth of salmon eggs, such as that recorded in Big Gulch, is typically associated with high mortality rates and may impact recruitment at later life stages of salmon populations (Schuett-Hames, et al. 1996). These conditions may contribute to the erratic runs that, like the water quality assessments, vary much more widely in Big than Japanese Gulch. Maintaining sustainable salmon runs in Japanese and Big Gulch may depend upon moderating flows and bioremediation of stormwater through structures such as rain gardens and other techniques of low-impact development in the upper watershed as well as re-introducing meanders to the lower reach of Big Gulch similar to the restoration in Japanese Gulch. Requiring low-impact development in new construction and retrofitting of older neighborhoods in the upper watershed may be helpful in achieving the most value from investments in habitat restoration in the lower reaches.

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[17] pH measurements by Saltwater Anglers of Mukilteo between 1991 and 1998 ranged between 6.5 and 8.0 with 7.5 the most common measurement (Jacobson 1991-1998).

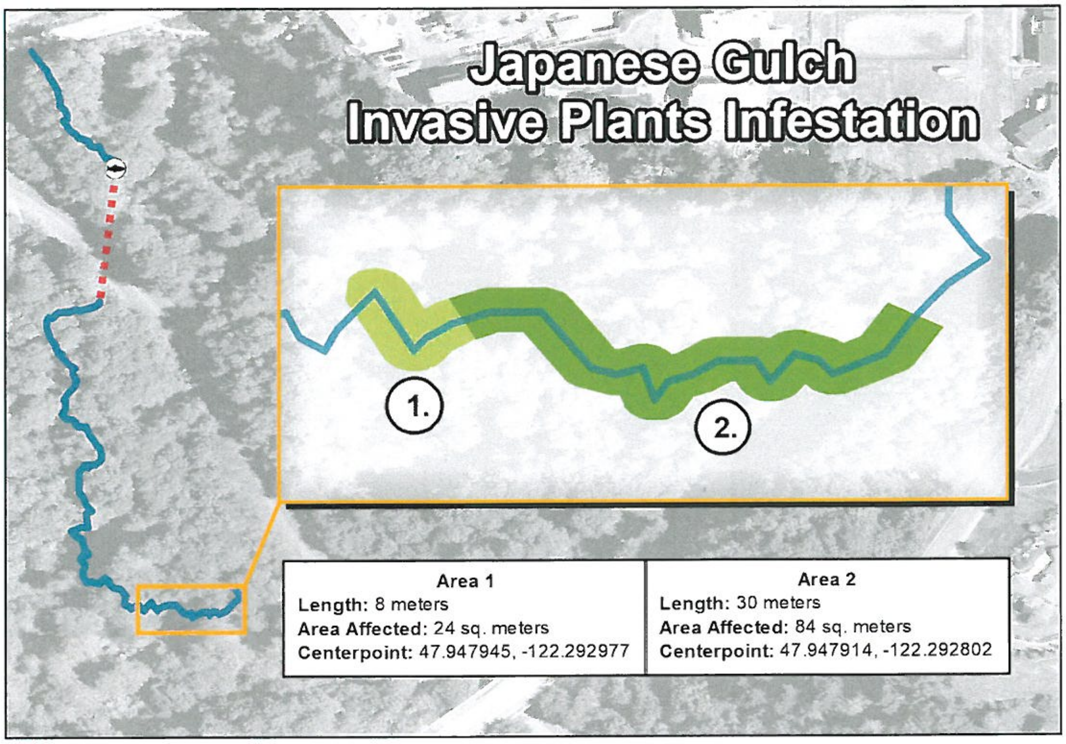

Figure 30. Japanese Gulch Invasive Plants Infestation, 2017.

1. Light Green: ~40% of stream habitat encroached by *S. dolcamera*.
2. Dark Green: ~90% of stream habitat encroached by *S. dolcamera*.

An invasion of bittersweet nightshade (*Solanum dulcamara)*, combined with the perennial problem of Himalayan blackberry (*Rubus armeniacus)* and English Ivy (*Hedera helix)*, into the newly restored habitat in Japanese Gulch remains an urgent concern. As reported in 2017 significant portions of prime spawning habitat are no longer accessible to salmon because of extensive mats of *S. dulcamara* covering the stream. Intriguingly, bittersweet nightshade is heaviest on the south side of the stream, and Himalayan blackberry dominates the north side. The mats were so thick at the start of the survey that researchers for the past two years had to cut through them with loppers and pruners in order to create a walkway necessary to conduct the surveys. This partial removal may have helped the salmon but left the banks overrun with invasive vegetation which will return to the streambed without corrective efforts in the coming spring and summer. Compare and contrast image 17 & 18 taken from approximately the same location in 2013 and 2017. The stream, including its large rocks and woody debris, is not even visible in the section in between the two surveyors, Siemng Sun and Chris Shipway, portrayed in the 2013 image. See also image 1, a perpendicular view from a little further upstream in 2018. Figure 30 identifies patterns of invasive species along the survey section of Japanese Gulch, recommending specific areas for targeted removals impinging on the restored spawning habitat.

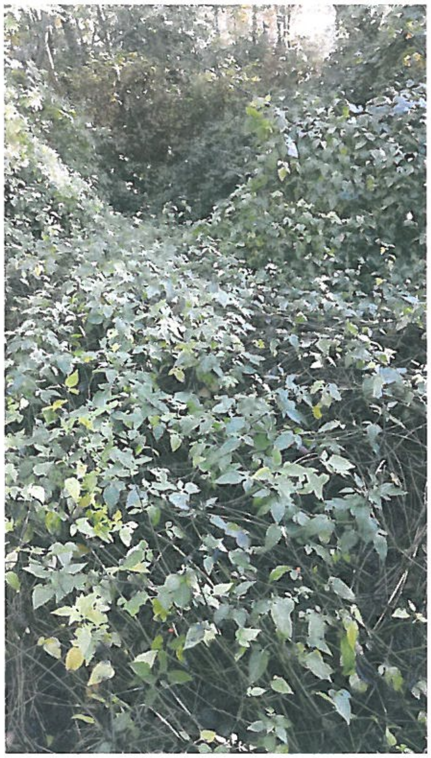

Image 17: Left - Bittersweet nightshade obstructing spawning habitat in Japanese Gulch, 2017. Image 18: Right - Siemng Sun and Chris Shipway in the stream amidst boulders and woody debris in the stream from approximately the same location.

Wildlife tracking and motion-sensitive camera images continue to reveal the presence of salmon predators. The returning salmon appear to be helping to feed an entire ecosystem. The deployment of motion activated cameras to monitor salmon carcass scavenging, complemented by tracking, added to previous wildlife tracking data by capturing images of predation in action from river otter, raccoon, coyote, bald eagle, and red-tailed hawk. Continued observations of wildlife using these urban watersheds indicate the importance of habitat goes well beyond fish. Big and Japanese Gulch are important wildlife habitat corridors in south Snohomish County that support squirrels, rabbits, mountain beavers, coyotes, deer, raccoons, opossums, and occasionally even black bear. Questions remain as to how effectively these corridors are connected to each other and to others in the region.

The lack of adequate corridors between islands of habitat such as those at Japanese and Big Gulch probably contributed to the alarm of residents when a black bear need to cross streets, businesses, and back yards to move through urban areas. Restoration and conservation efforts might be focused on ensuring the ability of species to move safely between these habitats and other wildlife corridors in the county and beyond. Mukilteo's attention to the need for wildlife corridors sets the city apart from other municipalities in the region (Murphy, et al., 2015, 95) but more options for wildlife are clearly needed and collaborations with neighboring cities would improve effectiveness of animals to move through green belts in urban areas.

Wildlife cameras have also documented the impact of off-leash domestic dogs on wildlife in the area. A motion activated camera captured a coyote running across the frame, followed by a

large domestic dog within 2 seconds (see image 15). Off-leash domestic dogs are disruptive to local wildlife and have generated complaints from other users of Mukilteo parks (Johnson 2017; Tennant 2018; Wilkinson 2018). This is especially true of dogs that are allowed to roam off-leash and off-trail, as is so often documented by our motion activated wildlife cameras. Trackers also frequently observe this behavior in person on wildlife surveys at the South Fork Japanese Gulch Trailhead. Off-leash, free-roaming dogs cause excessive stress to endemic wildlife and potentially expose wildlife to harmful pathogens for diseases such as rabies, CDV, and parvovirus (Woodroffe, 1999; Young, et al. 2011). Harmful effects of stress on many species of wildlife include habitat displacement, lack of prey species for predators, and lack of breeding success of more sensitive species such as ungulates (Gingold et al. 2009; Young et al. 2011). Domestic dogs appear as the sixth highest species detected at Big Gulch (Fig. 14) and the fourth highest in Japanese Gulch (Fig. 15). None of the cameras that detected these domestic dogs are located on trails frequented by humans, rather they are on animal trails. All of these instances of domestic dog were off-trail, and nearly all were off-leash, unsupervised by humans. In Japanese Gulch the frequency of these domestic dog detections are nearly as numerous as the detections of raccoon, one of the most prevalent wildlife species.

The willingness of the City of Mukilteo and Snohomish County Airport to partner with Edmonds CC provides additional educational value to this project. Over the course of seven years 805 different faculty, staff, students, and community members have contributed to this project. Students participating in the project have reflected positively on the value of hands-on service-learning and community-based research for the effectiveness of their learning. Some students have volunteered every year since the beginning of the project in 2012. Sierra Rudnick has logged more volunteer hours on the salmon monitoring surveys than any other student volunteer. She reflects on her experience with this project.

> I first started volunteering with the LEAF School in Fall Quarter of 2012. I had heard about the project from the park ranger at Meadowdale Beach County Park where I worked on stream restoration and salmon monitoring there. Being able to spot and document the first returning coho salmon in Japanese Gulch ... was exciting for me because was it the first time in decades salmon had been spotted spawning further up thanks to a new salmon ladder that was installed. This is a great opportunity for any college students who are interested in wildlife biology or marine biology to participate in. This survey is extremely important in monitoring the ecosystem and the concern of toxins in the water that affect the fish, and how that contributes to marine predators that feed on them, especially with the issues of the health of our local orcas pods.

A selection of quotes from students illustrates the impact of these experience on their learning about themselves, their communities, and the plants and animals with whom they share this place.

My “aha moment” this quarter was the realization that I have been citizen scientist my entire life, and I feel more prepared than ever to get away from my books and participate with others in learning about and protecting my natural world.

Loss of the specialized knowledge of nature is of grave concern for many indigenous communities around the world, which makes the work being done by the LEAF School and City of Mukilteo in service learning projects such as monitoring wildlife activity for habitat restoration and conservation efforts so, notable, important, and ultimately inspiring. It also makes me proud to be a Mukilteo resident.

I was never an outdoor person but going out to the Big Gulch and actually use tracking skills in real life was a very amazing thing … . The moment when I could see the difference between different tracks and actually name some of the species is unforgettable.

I never really considered that the average citizen could do science and aid in scientific research outside of a classroom.

Before we found the cameras -- to my delight -- a member of our group spotted a coyote print. This was my very first experience tracking any kind of wildlife even though I have spent a great amount of time in nature and enjoy it very much. I have learned through this experience that tracking is like a lost art.

The second service-learning activity I participated in was the water quality testing at the Japanese and Big Gulch streams in Mukilteo. This was the event that truly made me realize the importance of citizen science.

We heard a hiss-like bird noise that Grace said belonged to an immature barred owl. This noise is used when the owlet feels threatened and alerts the mother and family. As we approached the noise we spotted the owlet sitting on a branch high in a tree, tweaking and moving it’s head in circular motions to get a better look at us. Soon after we arrived the mother owl joined her child, watching us more defensively than her curious owlet. A third juvenile owl, sitting in a farther off tree became visible to us after some time. While we watched and clamored from below, the mother hooted and seemed to bridge the space between her children.

I saw coyote pups playing in the middle of the night, the migration of a pair of raccoons over the gulch as they moved from one place to another every few weeks, and the incredible image of an owl that happened to land on its prey directly in front of the camera.

Being in nature and feeling a connection to it lit a fire in me to care even more about this beautiful planet of ours. Seeing the tracks of the animals and their images on the

> cameras in their natural habitat reminded me that we are not alone, and that we not only need to preserve this planet for ourselves but for the many other beautiful creatures that inhabit it. I wholeheartedly believe that if everyone could experience what I experienced and felt a connection once again to the earth and all of its inhabitants, they would realize the importance of the nature-culture nexus and be more willing to preserve it for future generations.

> Being in the streams and counting the salmon brought to life the idea of First Salmon ceremonies. Having a fish the size of my torso swim between my feet and witnessing another form of life and knowing what that life means to the Coast Salish tribes tied together a quarter of learning about traditions different from mine. Thinking of the salmon I was counting in the context of that salmon being someone's ancestor and being sacred to an entire group of people brought perspective that helped me appreciate the traditions and see them in real life, instead of reading about rituals in a book.

> The most memorable service-learning experience to me is water quality monitoring, as it connects to articles I read about Minidoka. I learned that Japanese used to live in Mukilteo, and later in the Seattle area. After Pearl Harbor was attacked they were sent to the concentration camp in Idaho, called Minidoka and never returned until after the war. ... Visiting Japanese Gulch makes me think of Minidoka.

Service-learning students have become more familiar with the fish and wildlife in their own neighborhoods and have learned first hand about the role of local municipalities and citizen science in protecting and preserving salmon habitat and cultural diversity. The service-learning activities change student lives at the same time they make an impact in our local community. Science becomes not just a discipline of study in college, but a means for citizens to participate in the governance of their own communities. They learn that their everyday activities at home, in their yards and gardens, and on the roads have profound impacts upon the fish and wildlife with whom they share a neighborhood.

The cultural significance of Japanese Gulch, in particular, helps students to appreciate and understand more deeply communities often marginalized in their educational experience. Students are proud to know that even when faced with the injustices in our history that they can contribute to undoing some of the damage caused by broken treaties and racially motivated incarcerations. This is the stream closest to the site of the signing of the Point Elliot Treaty, an agreement that promised Coast Salish nations the right to continue to fish in return for the land upon which the students reside today. Students have made a real impact by helping repatriate salmon to Japanese Gulch. Students can also honor the memory of Japanese Americans who once thrived in Mukilteo but later suffered incarceration and internment during World War II by helping to care for the place and artifacts they left behind. Through their service-learning experiences in Japanese and Big Gulch students learn that people, plants, and animals are deeply interconnected and we need to care for each other if we are all to have a future together.

Image 19: Word cloud generated from student reflections on their service-learning experiences with people, fish, wildlife, and water quality monitoring in Japanese and Big Gulch during 2017.

Conclusion

The efforts of the City of Mukilteo and Snohomish County Airport to protect and restore Japanese and Big Gulch are important endeavors reaping tangible benefits for people, fish, and wildlife. The investment of the airport and city in the removal of barriers to salmon access in Japanese Gulch has helped salmon repatriate to Point Elliott; yet, the viability of salmon populations in bəka'ltiu over the next seven generations remains precarious. Students are making valuable contributions to these efforts through their citizen science in the community, their conservation efforts at home, and their study of social and environmental justice in the classroom. More effective management of stormwater in household activities and municipal infrastructure is necessary for maintaining the viability of both streams for rearing salmon. Riparian zones along the streams provide valuable habitat for a diversity of mammals, birds, amphibians, and reptiles. Small runs of spawning salmon in the heart of urban Mukilteo need continuing vigilance and care to ensure that future generations of people and salmon can continue to share these vital ecosystems at the edge of the Salish Sea.

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GIS Source Notes

Software

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Original Maps (In order of appearance)

Skyler Elmstrom. "Site Overview" PNG. No Scale. "A Survey of Fish and Wildlife: Japanese and Big Gulch". January 12th, 2019.

Skyler Elmstrom. "Big Gulch. Survey Area. Salmon Monitoring Area." PNG. Various Scales. "A Survey of Fish and Wildlife: Japanese and Big Gulch". January 12th, 2019.

Skyler Elmstrom. "Japanese Gulch. Survey Area. Salmon Monitoring Area" PNG. Various Scales. "A Survey of Fish and Wildlife: Japanese and Big Gulch". January 12th, 2019.

Skyler Elmstrom. "2018 Big Gulch Salmon Results" PNG. No Scale. "A Survey of Fish and Wildlife: Japanese and Big Gulch". January 12th, 2019.

Skyler Elmstrom. "2018 Japanese Gulch Salmon Results" PNG. No Scale. "A Survey of Fish and Wildlife: Japanese and Big Gulch". January 12th, 2019.

Data

LEAF School Geodatabase. Created by Ashley Pickard, Josh Popelka, & Steven Wagner. Updated and maintained 2015-2019 by Skyler Elmstrom.

Mukilteo Vector and Raster Data. City of Mukilteo Planning & Community Development.

Snohomish County Maps & GIS Data. Snohomish County Enterprise GIS Collaboration Team. WMS: http://gismaps.snoco.org/snocogis/services

National Hydrography Dataset. USGS. http://nhd.usgs.gov/

Appendix A: Water Quality Methods

In order to perform chemical analysis following the GWW procedures, the teams used the following kit: Alabama Water Quality Monitoring Kit LaMotte Code 9844-02.The procedures for conducting chemical and physical analysis of each stream's water quality are as follows:

Alkalinity Procedure

A volunteer fills a single test tube with stream water and then adds a BCG-MR tablet. An alkalinity reagent is then titrated into the test tube until the solution turns pink. The amount of drops required for this step is multiplied by 5 and recorded on the datasheet.

Bacteriological Testing

Volunteers collected small samples of streamwater to be plated with EasyGel Coliscan onto pretreated petri dishes. After allowing the samples to harden (at least 90 minutes), the petri dishes were placed inside of an incubator set to 37C for 48 hours. E. coli presence was indicated by the presence of blue colored colonies while other coliforms were indicated by the presence of red colonies.

Dissolved Oxygen (DO)

To test DO levels, a volunteer would simultaneously submerge two sampling bottles and cap them once full. Proceeding with one bottle, a stabilizer is added (Manganous Sulfate), followed by Alkaline Potassium Iodine Azide to form a brown precipitate. The bottle is then capped and inverted several times to mix its contents. At this time, the bottle rests until the precipitate settles below the shoulder of the bottle. Following settling, sulfuric acid is added and mixed by inverting until the precipitate dissolves completely. Once the sample is dissolved, a volunteer extracts a small portion of the bottle and adds starch indicator to that potion until the solution turns dark blue or black. The solution is then carefully titrated with Sodium Thiosulfate until the solution turns clear. The amount of drops required to turn the solution clear is then recorded on the data sheet. This process is repeated with the second sample bottle for redundancy and error checking. Percent dissolved oxygen calculated according to the temperature and solubility conversion factor found at https://dep.wv.gov/WWE/getinvolved/sos/Pages/DOSat.aspx.

Hardness Procedure

Using sample stream water, volunteers added drops of Hardness Reagent followed by a tablet of a second reagent. After shaking to ensure the reagent tablet dissolved, a third reagent was then titrated into the sample until the solution color stopped changing. The amount of titration necessary until color change stopped was then recorded.

pH

To determine pH, volunteers filled a test tube with stream water and then added a predetermined amount of Wide Range Indicator solution. The color of the stream water would then change color and could be compared to the pH chart. The result was recorded based off of the respective color's pH unit value.

Temperature (water)

Temperature was obtained using a mercury-free thermometer which was tied to a cord and left in-stream for at least 20 minutes. The Celsius value displayed was then recorded.

Turbidity

Utilizing turbidity columns, one filled with stream water as well as one filled with purified water as a control (bottled drinking water), volunteers assessed stream turbidity. A small dose of the Standard Turbidity Reagent was added repeatedly to the control column until the dot became more hazy than the stream sample column. This dosage, once an adequate haziness was observed in the control, was then recorded.

Macroinvertebrates

Student volunteers collect approximately 100 macroinvertebrates from the stream bed by rubbing the bottom of the stream and letting loose sand, gravel, vegetation and macroinvertebrates float into a D-net. They sort contents of the D net and the group macroinvertebrates according to category defined by Global Water Watch (example: caddisfly, mayfly, sowbug). Calculating the biotic index only requires reporting the presence or absence of each category.

Appendix B: Comprehensive List of Documented Fish and Wildlife[18]

Big Gulch

Fish

Chinook Salmon* (*Oncorhynchus tshawytscha*), Chum Salmon** (*O. keta*), Coho Salmon** (*O. kisutch*), Cutthroat Trout* (*O. clarkii*).

Mammals

Black-Tailed Deer** *(Odocoileus hemionus columbianus)*, Black Rat *(Rattus rattus),* Bushy-Tailed Woodrat *(Neotoma cinerea)*, Coyote** *(Canis latrans)*, Deer Mouse *(Peromyscus maniculatus)*, Douglas's Squirrel *(Tamiasciurus douglasii)*, Eastern Gray Squirrel *(Sciurus carolinensis)*, Flying Squirrel *(Glaucomys sp?),* Meadow Vole *(Microtus pennsylvanicus),* Mountain Beaver *(Aplodontia rufa)*, Northern River Otter *(Lontra canadensis)*, Pacific Jumping Mouse *(Zapus trinotatus)*, Raccoon** *(Procyon lotor)*, Shrew (species unconfirmed), Virginia Opossum** *(Didelphis virginiana)*.

Birds

American Crow *(Corvus brachyrhynchos)*, American Robin *(Turdus migratorius)*, Anna's Hummingbird *(Calypte anna)*, Bald Eagle** *(Haliaeetus leucocephalus)*, Black-Capped Chickadee *(Poecile atricapillus)* California Quail *(Callipepla californica)*, Golden-Crowned Kinglet *(Regulus satrapa)*, Great Blue Heron** *(Ardea herodias)*, Hairy Woodpecker *(Picoides villosus),* Killdeer *(Charadrius vociferus)*, Pacific Wren *(Troglodytes pacificus)*, Pileated Woodpecker *(Dryocopus pileatus)*, Red-Tailed Hawk** *(Buteo jamaicensis)*, Sharp-Shinned Hawk *(Accipiter striatus)*, Song Sparrow *(Melospiza melodia)*, Spotted Towhee *(Pipilo maculatus),* Steller's Jay *(Cyanocitta stelleri),* Varied Thrush *(Ixoreus naevius)*, White-Crowned Sparrow *(Zonotrichia leucophrys)*.

Amphibians

Pacific Chorus Frog (*Pseudacris regilla*).

Reptiles

Northwestern Garter Snake (*Thamnophis ordinoides*).

Japanese Gulch

Fish

Coho Salmon** (*Oncorhynchus kisutch*), Chum Salmon* (*O. keta*), Cutthroat Trout* (*O. clarkii*).

Mammals

[18] In preparing this final comprehensive report the authors noted a few errors that had creeped into these lists in previous annual reports. These included species inadvertently left off the list, misspellings, and misused asterisks. This final report corrects those errors. Additionally, some track identifications do not permit species level verification but they do support evidence of animals that have been identified at species level by Mukilteo Wildlife Society members. The LEAF School's wildlife trackers, for example, have documented salamander tracks in Japanese Gulch and shrews and meadow voles in Big Gulch,

American Shrew Mole *(Neurotrichus gibbsii)*, Big Brown Bat* *(Eptesicus fuscus)*, Black bear (*Ursus americanus*), Black-tailed deer** *(Odocoileus hemionus, subsp. Odocoileus hemionus columbianus)*, Black Rat* *(Rattus rattus)*, California Myotis* *(Myotis californicus)*, Coast Mole** *(Scapanus orarius)*, Coyote** *(Canis latrans)*, Creeping Vole* *(Microtus oregoni)*, Douglas's Squirrel** *(Tamiasciurus douglasii)*, Eastern Cottontail** *(Sylvilagus floridanus)*, Eastern Gray Squirrel** *(Sciurus carolinensis)*, Flying Squirrel* *(Glaucomys sp?)*, Little Brown Bat* *(Myotis lucifugus)*, Long-tailed Vole* *(Microtus longicaudus)*, Mountain Beaver** *(Aplodontia rufa)*, Muskrat** *(Ondatra zibethicus)*, North American Beaver* *(Castor canadensis)*, North American River Otter *(Lontra canadensis)*, Northern Raccoon** *(Procyon lotor)*, Norway Rat* *(Rattus norvegicus)*, Pacific Jumping Mouse* *(Zapus trinotatus)*, Pacific Water Shrew* *(Sorex bendirii)*, Red Fox* *(Vulpes vulpes)*, Townsend Chipmunk** *(Neotamias townsendii)*, Townsend's Mole** *(Scapanus townsendii)*, Townsend's Vole** *(Microtus townsendii)*, Trowbridge's Shrew* *(Sorex trowbridgii)*, Virginia Opossum** *(Didelphis virginiana)*, Western Spotted Skunk* *(Spilogale gracilis)*.

Birds

American Bushtit** *(Psaltriparus minimus)*, American Crow** *(Corvus brachyrhynchos)*, American Dipper (*Cinclus mexicanus*), American Goldfinch* *(Spinus tristis)*, American Robin** *(Turdus migratorius)*, Anna's Hummingbird** *(Calypte anna)*, Bald Eagle** *(Haliaeetus leucocephalus)*, Band-Tailed Pigeon* *(Patagioenas fasciata)*, Barn Swallow* *(Hirundo rustica)*, Barred Owl** *(Strix varia)*, Belted Kingfisher** *(Megaceryle alcyon)*, Bewick's Wren** *(Thryomanes bewickii)*, Black-Capped Chickadee** *(Poecile atricapillus)*, Black-Headed Grosbeak* *(Pheucticus melanocephalus)*, Black-Throated Gray Warbler* *(Setophaga nigrescens)*, Brown-headed Cowbird* *(Molothrus ater)*, Brown Creeper* *(Certhia americana)*, Bufflehead *(Bucephala albeola)*, Canada Goose* *(Branta canadensis)*, Cedar Waxwing* *(Bombycilla cedrorum)*, Chestnut-Backed Chickadee** *(Poecile rufescens)*, Cliff Swallow* (*Petrochelidon pyrrhonota*), Common Yellowthroat* *(Geothlypis trichas)*, Cooper's Hawk* *(Accipiter cooperii)*, Dark-Eyed Junco** *(Junco hyemalis)*, Downy Woodpecker* *(Dryobates pubescens)*, European Starling* *(Sturnus vulgaris)*, Golden-Crowned Kinglet* *(Regulus satrapa)*, Golden-crowned Sparrow (*Zonotrichia atricapilla*), Great Blue Heron** *(Ardea herodias)*, Green-Winged Teal *(Anas carolinensis)*, Green Heron* *(Butorides virescens)*, Hairy Woodpecker** *(Picoides villosus)*, Hammond's Flycatcher* *(Empidonax hammondii)*, Hermit Thrush** *(Catharus guttatus)*, Hooded Merganser (*Lophodytes cucullatus*), House Sparrow* *(Passer domesticus)*, Hutton's Vireo* *(Vireo huttoni)*, Mallard** *(Anas platyrhynchos)*, Nashville Warbler* *(Oreothlypis ruficapilla)*, Northern Flicker** *(Colaptes auratus)*, Olive-Sided Flycatcher* *(Contopus cooperi)*, Orange-Crowned Warbler* *(Oreothlypis celata)*, Osprey* *(Pandion haliaetus)*, Pacific Slope Flycatcher* *(Empidonax difficilis)*, Pacific Wren** *(Troglodytes pacificus)*, Peregrine Falcon* *(Falco peregrinus)*, Pileated Woodpecker** *(Dryocopus pileatus)*, Pine Siskin* *(Spinus pinus)*, Purple Finch* *(Haemorhous purpureus)*, Red-Breasted Nuthatch** *(Sitta canadensis)*, Red-Breasted Sapsucker** *(Sphyrapicus ruber)*, Red-tailed Hawk* *(Buteo jamaicensis)*, Red-winged blackbird* (*Agelaius phoeniceus*), Ruby-Crowned Kinglet* *(Regulus calendula)*, Rufous Hummingbird* *(Selasphorus rufus)*, Sharp-Shinned Hawk* *(Accipiter striatus)*, Song Sparrow** *(Melospiza melodia)*, Spotted Towhee* *(Pipilo maculatus)*, Steller's Jay* *(Cyanocitta stelleri)*, Swainson's Thrush** *(Catharus ustulatus)*, Townsend's Warbler* *(Setophaga townsendi)*, Tree Sparrow* *(Passer montanus)*, Varied Thrush* *(Ixoreus naevius)*, Violet Green Swallow* *(Tachycineta thalassina)*, Western Screech Owl* *(Megascops kennicottii)*, Western Tanager* *(Piranga ludoviciana)*, Western Wood Pewee* *(Contopus sordidulus)*, White-Crowned Sparrow** *(Zonotrichia leucophrys)*, Wilson's Warbler* *(Cardellina pusilla)*, Yellow Warbler* *(Setophaga petechia)*.

Reptiles

Northwestern Garter Snake* (*Thamnophis ordinoides*).

Amphibians

Long-Toed Salamander* *(Ambystoma macrodactylum)*, Northern Red-Legged Frog *(Rana aurora)*, Northwestern Salamander* *(Ambystoma gracile)*, Pacific Chorus Frog* *(Pseudacris regilla)*.

**Indicates species previously recorded by Mukilteo Wildlife Society (MWS), Adopt-A-Stream Foundation (AASF), Skagit River System Cooperative (SRSC), or Saltwater Anglers of Mukilteo (SWAM). Data from the last group was not available for previous annual reports.*

*** Indicates species recorded by the LEAF School and at least one of the other groups: MWS, AASF, SRSC, or SWAM.*

No asterisk indicates species are solely recorded by the LEAF School.